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REVIEW ARTICLE

Research Progress of Nanostructured Lipid Carriers in Ocular Drug Delivery

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Abstract: The eye is the most important sensory organ, which restricts most of the active substances due to its static and dynamic barriers. The application of conventional eye drop is still popular, but it was found to be less permeable to both anterior and posterior eye portions, requiring more frequent administration. It seems to be a great challenge for the researcher to fabricate an ocular formulation that crosses the barriers and achieves an optimal therapeutic concentration at the ocular globe. Recent studies revealed that a nanostructured lipid carrier has great potential in ophthalmic use and has become more popular due to its permeability in the eye cavity.

This review describes the nanostructured lipid carriers with respect to the mechanism of ocular permeation, structural feature, manufacturing process, characterization, and its merits over other nanocarriers. In recent years, newly nanostructured-based ocular formulations have been developed, like surface-modified with various cationic compounds and their integration with different polymeric systems, to enhance ocular bioavailability in both regions of the eye. Newly developed nanostructured lipid carriers include surface modified cationic lipid, polymers, and thiolated compounds, *etc.*, that increases mucoadhesive property. Finally, nanostructured incorporated forms, in *situ* gel, and hydrogel increase permeation in the posterior region of the eye.

Keywords: Lipid nanoparticles, NLC, ocular drug delivery, pre-corneal retention, mucoadhesive, zeta potential, ocular bioavailability, transcorneal permeation.

1. INTRODUCTION

The eye is a complex sensory organ of the human body and the most delicate organ, which is also recognized as the "window of the human soul". The eye is a specialized and structured organ, broadly divided into two parts, *i.e.*, the front part, which is known as the anterior segment, and the rear part, which is recognized as the posterior segment [1, 2]. Each of these broad regions is related to specific eye disease conditions. The disease and disorders associated with anterior segments are cataracts, anterior uveitis, dry eye disease, and glaucoma. In contrast, the posterior region may be associated with complications like Age-related Macular Degeneration (AMD) and diabetic eye disease, which have a known impact on the rear portion [3]. The delivery of the active substances to achieve the optimal concentration in the cavity of the eye is the most challenging task for researchers due to its unique structure and different ocular barriers that inhibit the entry of drug substances into the desired location [4]. Amongst the ocular preparations, eye drops are more frequently used for various complications of the eyes. However, they are cleared rapidly from the surface of the cornea by different mechanisms of tear dynamics like lachrymati dilution, and high tear turnover. Furthermore, the co sists the active substances due to the uniquely structu ers like corneal epithelium, substantia propria, and en um [3, 5]. All these factors contribute to the less ava (< 5 percent) of bioactive compounds in the eye ca Moreover, to attain optimal ocular concentration, f dosing is needed that ultimately reaches the systemic tion and produces unwanted effects [7, 8].

One of the significant limitations faced in ophthal livery is to attain the desired therapeutic concentratic target site of the eye for a sufficient duration of ti meeting such criteria, various eye formulations have tempted, which include eye ointments and ocular The precorneal retention time was found to be incre the application of ointment and ocular insert, but tl not used frequently due to blurred vision and lack of compliance, respectively [9, 10]. Moreover, eye ti stricts the drug, which is administered systemically the presence of different ocular barriers [11, 12]. Fc ery of a drug to the posterior region of the eye, the u travitreal and periocular routes has been recommen their use is limited due to invasive nature and poor