DCR based on SCLs

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Ophthalmic drug delivery has always been a challenge for ophthalmologists and scientists from a variety of disciplines. It is estimated that the bioavailability of ophthalmic drugs is uncertain and is about 5% or less. This is a consequence of anatomical and physiological barriers, including tear drainage and epithelial transport limitations. Unique static and dynamic eye barriers exclude the penetration of xenobiotics and discourage the active absorption of therapeutic agents. Designing an ideal delivery regimen should involve increased bioavailability and controlled drug release at the target tissue, overcoming the ocular barriers.

Eye medications administered in the conventional form of eye drops or ointments are often characterised by low bioavailability. In addition, they require repeated daily administration, which, combined with low patient compliance, causes doses to be avoided or administered incorrectly, contrary to therapeutic recommendations. Attempts to increase the bioavailability of ophthalmic medicines by using various modern solutions such as viscous solutions, suspensions, emulsions, ointments, gels, polymer inserts, and colloidal systems are still unsatisfactorily challenging in pharmaceutical research. Hence, the use of contact lenses as drug delivery systems has been increasingly explored in recent years.

The main objectives for the development of DCR (drug-controlled release) based on SCLs (soft contact lenses) are:

to increase the drug delivery efficiency;

to improve patient compliance and reduce undesirable systemic side effects, especially in chronic diseases such as glaucoma and dry eye;

to enhance SCLs tolerance, particularly in patients affected by dry eye syndrome and ocular allergies;

to design “bandage contact lenses” modified with antimicrobial or anti-inflammatory agents for managing corneal wound healing.

Keywords: contact lenses ; drug delivery ; drug-controlled release ; drug delivery systems based on contact lenses in ophthalmic therapies

1. Contact Lenses as Drug Delivery Systems

Contact lenses are hard or soft polymer devices designed to fit the cornea to correct refractive errors. They can be made of hydrophilic or hydrophobic polymers. Hydrogel contact lenses appear to effectively deliver drugs to the eye since they better absorb aqueous solutions [1]. Contact lenses offer higher bioavailability of the drug than other non-invasive ophthalmic medications, such as drops or ointments, due to the proximity of the contact lens to the cornea. They also provide a significant advantage in dosage over topical eye drops [2].

There are two main groups of contact lenses depending on the designed material: soft contact lenses–made of hydrogel or silicone hydrogel polymers, and rigid gas-permeable contact lenses (RGP) [3]. The soft materials for use as drug delivery systems are of more interest because of their hydrophilic properties, biocompatibility, and comfort of use [4][5]. For this reason, SCLs account for 87% of matches in clinical practice, as opposed to 13% of RGP contact lenses [6][7].

The physical and chemical properties of the polymers used are essential in the design and quality control of DDSCL. Polymers’ most critical physical properties for drug-releasing contact lenses are transparency, oxygen permeability, glass transition temperature, wettability, and water content [8].

2. Soft Contact Lenses Parameters

2.1. Transparency

The transparency of the contact lens is a crucial parameter determining its functionality and must not be impaired by the added drug. DDSCL developed using novel techniques such as molecular or supercritical solvent imprinting, liposome loading, and microemulsions showed good transparency [9].

2.2. Oxygen Permeability

Low oxygen transfer through the contact lens can result in serious side effects. Since the human eye is insufficiently oxygenated by the system of blood vessels, and the oxygen supply is mainly carried out through exposure to air, oxygen delivery and effective carbon dioxide removal must be carried out through the contact lens, ensuring gas circulation. Low-oxygen-transmissible SCLs further impede oxygen flow to the cornea with possible loss of corneal transparency upon overwear. The SCL oxygen permeability is defined as Dk (D multiplied by k), where D is the diffusion coefficient, and k is the partition coefficient of oxygen in the lens material.

The gas permeability of soft contact lenses has been improved by silicone-based polymer hydrogel lenses made of polydimethylsiloxane (PDMS). PDMS exhibits impressive permeability (Dk = 600 barrers) while maintaining comfort, wettability, and biofilm resistance compared to silicone-based hydrogel lenses. However, the long-worn contact lens must ensure oxygen permeability of not less than Dk > 87 barrers to avoid corneal hypoxia. Achieving Dk with conventional hydrophilic contact lenses on such a level is very difficult [8].

2.3. Glass-Transition Temperature

The glass transition temperature (Tg) is the temperature below which the physical properties of polymers change to those of a glassy or crystalline state. The Tg of contact lens material is expected not to change due to modification by the drug or application of other additives. Numerous studies show that different production methods of drug-delivering contact lens materials do not affect the Tg values. For example, the change in Tg after the addition of β-CD (β-cyclodextrin) was insignificant, suggesting that the addition of β-CD has little or no effect on the degree of hydrogel cross-linking or network stiffness [10]. Costa et al. [11] also found that the Tg of SCLs does not change due to the impregnation and release of the drug. On the other hand, Yanez et al. found no changes in the Tg values of SCL in the subsequent supercritical stages of fluid processing [12]. Therefore, it can be concluded that most of the DDSCL assembling methods allow the design of medicine charged lenses without changing their material's Tg [11].

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