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Drug Delivery System by Hydrogel Soft Contact Lens Materials: A Review

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Abstract

Hydrogel formulations were significantly explored over the last decade for the ophthalmic drug delivery applications through contact lenses. Hydrogels are the leading materials of soft contact lenses because of their biocompatibility and transparent characteristic. Several hydrogel materials have been investigated for soft contact lens-based ophthalmic drug delivery systems: Poly-2-hydroxyethylmethacrylate (p-HEMA) hydrogels, HPMA copolymer, Acrylamide (AAm) hydrogel, NHS–PEG–biotin hydrogel and Silicon hydrogel. Different types of hydrogels for these contact lens-based ophthalmic drug delivery systems, their advantages and drawbacks are critically analyzed in this review.

Keyword : Hydrogels, soft contact lenses, drug delivery systems

INTRODUCTION

The accomplishment of the therapy of eye ailments with ophthalmic medications unequivocally relies on upon achieving adequate drug concentration on the cornea for a sufficient period of time, yet the ordinary delivery of drugs by eye drops which currently account for more than 90% of all ophthalmic formulations which is very inefficient and in certain case leads to serious side effects [1, 2, 3]. Once the drug is instillated into the eyes, the drug acts on the fluid present in the tear film and has a short residence time of approximately 2 min in the film. Only about 5% of the drug is absorbed into the cornea and the remaining either gets absorbed in the conjunctiva or flows through the upper and the lower canaliculi into the lacrimal sac [4, 5]. This ingestion prompts drug wastage, and all the more significantly, the vicinity of specific ocular drugs in the circulation system prompts undesirable side effects. Besides, the use of ophthalmic medications by eye drops brings about a rapid variation in the medication delivery rates to the cornea and this restricts the adequacy of the therapeutic system [6, 7]. Furthermore, dosage through eye drops is conflicting and hard to regulate, as a large portion of the medication is discharged in a initial busrt of concentration [8, 9]. To expand the residence time of the medication in the eye, accordingly decreasing wastage and minimizing reactions, various researchers have proposed utilizing contact lenses for ophthalmic drug conveyance. A few methods have been proposed to make ophthalmic medications deliverable by soft contact lens. Hypothetical simulation anticipated that delivery of ophthalmic drug by contact lenses is around 35 times more proficient than by eye drops [10].

Regularly, contact lenses are initially produced for the rectification of refractive errors. Contact lenses are utilized as an optical device as well as a remedial solution for visual surface disorders. As of late, soft contact lenses are incidentally utilized for treating corneal and conjunctival illnesses, being utilized to keep the shedding of corneal epithelial cells and to shield from mechanical harm and to hold wettability of the ocular surface averting dissipation of the tear liquid. Recently, it is reported for the advantage of silicone hydrogel lenses for therapeutical utilization [11-22]. For the most part, hydrogels are three-dimensional, hydrophilic, polymeric networks which is fit for soaking up a lot of water or organic liquids [23, 24]. The systems are made out of homopolymers or copolymers, and are insoluble because of the vicinity of chemical substance crosslinks or physical crosslinks [25-30]. The recent give the system structure and physical integrity. These hydrogels display a thermodynamic similarity with water which permits them to swell in aqueous media [23, 24, 31-33].

Based on Jindrˇich Kopecˇek discovery, hydrogels were the first biomaterials intended for clinical utilization. His discovery and applications as soft contact lenses and implants are displayed. This early hydrogel research served as an establishment for the development of biomedical polymers research into new directions in which the design of stimuli sensitive hydrogels that abruptly change properties upon application of an external stimulus, for example, pH, temperature, dissolvable, electrical field, biorecognition and hydrogels as transporters for the conveyance of medications, peptides, and proteins. At last, pathways to self-gathering of block and graft copolymers into hydrogels of exact 3D structures are presented. Various methods have been proposed to accomplish drug delivery systems for effective therapy. Among them, hydrogels have attracted in impressive consideration as excellent candidates for controlled discharge devices, bioadhesive devices, or targetable devices of therapeutic agents [34].

TYPES OF HYDROGELS MATERIALS

Poly-2-hydroxyethylmethacrylate (pHEMA) hydrogels.

HEMA hydrogels were experimented as matrices for protein delivery [35]. If contact lenses made of this material are put on the eye, the drug will diffuse from the particles, go through the lens matrix, and enter the postlens tear film (POLTF), the slight tear film trapped between the cornea and the lens. In the vicinity of a lens, drug molecules would have an any longer residence time in the postlens tear film than the residence time of give or take 2 to 5 minutes that is the case with topical utilization of medications as drops [36-38]. Drug loaded p-HEMA hydrogels were synthesized by free radical arrangement polymerization of the monomers in vicinity of nanoparticles. The molecule loaded hydrogels were described by light-transmission and electron microscopy studies. In this study we captured medication loaded oil-in-water (O/W) microemulsions in p-HEMA gels. The mean molecule size of the oil drops was littler than 20 nm, and the gels were transparent. The particles isolated during polymerization and there were two sorts of areas in the gels. One sort had particles and the other sort was without particles Release profiles of lidocaine, a model hydrophobic medication, were measured by UV-Vis spectrophotometry. The amount of medication entrapped is sufficient to last more or less 3 to 4 days, which is additionally the period in which the vast majority of the medication is released by the lens. The measure of medication uptake stays steady for drenching times over 10 min. While the drug uptake onto the lenses is by and large rapid, the discharge happens over contrasting time compasses and at variable levels.

Approximately 5% of the medication instillated as drops infiltrates the cornea and achieves the visual tissue, though the

rest is lost to different organs in the body [9]. In this study he proposed to create expendable delicate contact lenses as another vehicle for ophthalmic medication conveyance. The fundamental thought was to typify the ophthalmic medications in nanoparticles and to scatter these medication loaded particles in the contact lens framework. In this study, he concentrated on delicate poly 2-hydroxyethyl methacrylate (p-HEMA) hydrogel lenses. The p-HEMA hydrogel network is combined by mass or arrangement free radical polymerization of HEMA monomers in the vicinity of a cross-linker, for example, ethylene glycol-di-methacrylate (EGDMA) [39]. If contact lenses made of this material are placed on the eye, the drug will diffuse from the particles, travel through the lens matrix, and enter the postlens tear film (POLTF), the thin tear film trapped between the cornea and the lens. In the presence of a lens, drug molecules would have an any longer residence time in the postlens tear film than the residence time of more or less than 2 to 5 minutes that is the situation with topical use of drugs as drops.

HPMA copolymer

Hydrogels produced by crosslinking of HPMA copolymer precursors with coiled-coil modules underwent dramatic volume transitions (de-swelling up to 10-fold) at the melting temperature of the coiled-coil modules [40]. HPMA copolymer based hydrogels were stimulated with captured anticancer drugs [41, 42].

Acrylamide (AAm) hydrogel

Li Xinming and Cui Yingde suggested that as the rate of AAm in the copolymer hydrogels increases, more chloramphenicol was ingested on account of higher water uptake. As the rate of AAm in the copolymer hydrogels and the pH estimation of the buffer solution decrease, more chloramphenicol was discharged from the copolymer hydrogels. In all the trials, the most part of medication was conveyed in the initial five hours. Migration rate of chloramphenicol was greater as the AAm content in the hydrogels increments in the first phase of diffusion procedure, and there was no significant contrast from that point. As the AAm content in the hydrogels expands, its swelling is higher. This is a direct result of the hydrophilic character of that monomer. In the same way, hydrogels composition affects the drug release process. The pH decrease supposes a higher ionization of the polymer networks, so there is a higher swelling and a faster release of chloramphenicol from the hydrogels [43].

Silicon hydrogel

Taking into account Eric Papasa's study, silicone hydrogel technology has expanded oxygen penetrability to the eye, with enhanced corneal and visual surface physiology being the outcome. A broad study of a new soft contact lens multipurpose solution shows to it is safe and has broad spectrum when utilized as a part of mix with 4 diverse silicone hydrogel lenses following 2-4 weeks of wear and the related tear deposition. The silicon-containing materials took up and discharged less cromolyn sodium, ketotifen fumarate,dexamethasone sodium phosphate and ketorolac tromethamine, than the p-HEMA-containing materials experimentated in this study. In spite of the lower uptake or discharge, the silicon containing materials could release a higher amount of cromolyn sodium and ketotifen fumarate than if the medication would have been delievred by topical eye-drop solutions. Moreover, the silicon-containing material, balafilcon showed characteristics that is more similar to p-HEMA containing materials. The drug uptake and discharge were influenced by the type of medication and the type of material. Ketotifen fumarate, an amphiphilic antihistamine, was the main drug that showed a maintained release with all the materials researched. A wide range of normal medication uptake was seen with cromolyn sodium having the most noteworthy normal uptake (7879 ± 684 g/lens) and dexamethasone sodium phosphate having the least normal uptake (67±13 g/lens). All medications explored showed a halfway arrival of the medication taken up with the exception of dexamethasone sodium phosphate where no discharge was distinguished [2].

Karlgard recommended that the in vitro uptake and release of ciprofloxacin from silicone-based hydrogel and conventional pHEMA-based hydrogel contact lenses was inspected by spectrophotometric assessment of the drug fixation in saline solution. The silicone-based hydrogel lenses discharged a lower measure of medication than CH lenses (72 versus 168 μg/lens). Ionic lenses release less medication than non-ionic lenses (127 versus 151 μg/lens) [21, 44, 45]. Chetoni et al. reported silicone elastic/hydrogel composite ophthalmic additions. Poly(acrylic corrosive) or poly (MAA) IPN was joined on the surface of the additions to accomplish a mucoadhesive property. The visual maintenance of IPN-united additions was significantly higher regarding ungrafted ones. An in-vivo study utilizing rabbits demonstrated a drawn out arrival of oxytetracycline from the additions for a few days [46].

NHS–PEG–biotin hydrogel

NHS–PEG–biotin molecules being bonded onto the surface amine bunches via carbodiimide science. Neutravidin was then reinforced onto the PEG–biotin layer, and liposomes containing PEG-biotinylated lipids were docked onto the surface-immobilized Neutravidin. Continuous expansion of further Neutravidin and liposome layers empowered creation of multilayers. Multilayers of liposomes were additionally created by exposing contact lenses covered with Neutravidin to liposome totals delivered by the expansion of free biotin in solution. The release energy of a fluorescent color showed that in place liposomes had been immobilized onto the contact lens surface, with the stability demonstrating temperature reliance. The surface-bonded liposomes can be accumulated to 1 month at 48 ^{0}C with little release of their substance. The multilayer plan used gives solid interfacial holding, comprising of either covalent holding or biotin or avidin fondness between the individual layers, along these lines minimizing the danger of liposome separating from contact lens surfaces. The downsides of this technique incorporate the danger of the liposomes withdrawing from contact lens surface, and the multilayer plan of the liposomes diminishes the oxygen penetrability, despite the fact that the danger of the liposomes detaching from the surface can be lowered. The release rate of ophthalmic medications from liposomes was found to show a conduct characteristic of dispersion control, hence the discharge profile is hard to direct [47].

CONCLUSION

It is evaluated that almost 100 million individuals wear contact lenses and the number is as yet expanding. In spite of the fact that contact lenses are intended to right ametropia, they additionally indicate extraordinary point of view as remedial devices for delivery of ophthalmic medications. A perfect contact lens-based ophthalmic drug delivery system would have the limit of stacking expansive measure of medications and controlling the discharge in zero-order discharge profiles without impacting its own properties, for example, shape holding, transparency stability, and oxygen penetrability. The modification either during or after the manufacture of hydrogel contact lenses including Poly-2-hydroxyethylmethacrylate (p-HEMA) hydrogels, HPMA copolymer, Acrylamide (AAm) hydrogel, silicon hydrogel and NHS–PEG–biotin hydrogel. The recent presentation of silicon-containing hydrogel contact lens materials with essentially higher oxygen permeabilities than ordinary p-HEMA-based materials has

brought about another scope of soft contact lens materials accessible to practioners. The outcomes demonstrate that the poly (HEMA-co-AAm) hydrogels are valuable delicate contact lens biomaterials as far as light transparency in the scope of visible light wavelength contrasted with HPMA copolymer,silicon hydrogel or NHS–PEG–biotin hydrogel. Light transparency in the scope of light wavelengths being more than 94% demonstrates that the hydrogels are valuable biomaterials for the creation soft contact lenses.

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