Formulation and Characterization of Poly Sulfoxyamine Grafted Chitosan Coated Contact Lens

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Authors’ contributions

This work was carried out in collaboration among all authors. Authors RLJ and SGS designed the study and prepared the primary draft. Authors MVP and SNS managed the analyses of the study. Author SNB managed the literature searches. All authors were participated in the execution of laboratory study. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The aim this research work is to formulate and characterize Poly Sulfoxyamine Grafted Chitosan Coated contact Lens.
Methodology: Poly Sulfoxyamine Grafted Chitosan was used for coating the Lens & converting it in to Antimicrobial Lenses. Poly Sulfoxyamine Grafted Chitosan was performed in the presence of pyridine and further treatment with ammonia during reaction of Thionyl chloride & chitosan. The UV light interference, visible light transmission and antimicrobial evaluation were studied.

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**Results:** The results indicate that Contact lenses prepared with Modified Poly Sulfooxyamine Grafted Chitosan absorbed some UV radiation & does not interfere with visible region. Due to the antimicrobial activity of modified Chitosan, the growth and transmission of micro organisms are reduces in coated Lens as compared to uncoated Lens.

**Conclusion:** On basis of the results we concluded that Modified Poly Sulfooxyamine Grafted Chitosan might be used as coating material or material for making contact Lenses which will be less susceptible for microbial contamination.

**Keywords:** Poly sulfooxyamine grafted chitosan; contact lens; antimicrobial activity; UV light; chitosan.

1. INTRODUCTION

Contact lenses are emerging as an alternative ophthalmic drug delivery system to resolve the shortcomings of the Conventional / Topical application methods like eye drops and ointments. The use of contact Lens is so wide spread worldwide [1]. Contact Lenses related microbial keratitis and other microbial infections may involve several millions of peoples and therefore must be considered a major health threat. Contact Lens induced microbial keratitis due to bacterial transmission from one surface to another [2]. Contact lenses for ophthalmic drug delivery have become very popular, due to their unique advantages like extended wear and more than 50% bioavailability. To achieve controlled and sustained drug delivery from contact lenses [3].

Due to the frequent use of contact Lenses, there is an increase the microbial load in the eye which can adversely affect to the corneal health [4]. It has been observed to be significant risk like keratitis due to the poor contact Lens hygiene & microbial contamination of the Lens storage. Wearing old contacts, contact at night or contact that does not fit well can scratch the surface of cornea. This can also put a risk of infection. Other problems related to the contact Lens includes decreased oxygen transmission [4] tighten fitting Lenses [5,6]. Increased surface depositions [7] change in Lens power and decreased vision performance [8,9].

A wide variety of antimicrobial technologies could potentially be employed for use with a contact Lens. Some may be applied to the surface of the Lens material, while others may be infused directly into the Lens polymer, an ideal antimicrobial Lens will be non toxic to the cornea & other tissues, and would provide broad spectrum activity along with minimal impact on the normal ocular flora. There are several antimicrobial surface technologies are used in contact Lens. The silver impregnated Lens which slowly releasing silver ions into the solution to maintain an antimicrobial surface [10]. Polymeric quaternary ammonium compounds [polyquates] have been used in contact Lens solution as disinfectants, preservative & algaecides Another broad spectrum antimicrobial agent is polymeric pyridinium compounds which covalently bounded to the surface to the Lens. The long amphipathic polycationic chains penetrated in the bacterial cell wall upon contact with bacteria & acts as antimicrobial polymer [11]. The selenium compounds & nitric oxide releasing polymers are free radical producing agents which coated on Lens & showed antimicrobial property [12]. Another class of agents is Quorum – sensing compound which potentially used for antimicrobial coating material to the Lens [13]. Other types of anti infective agents may be used to kill the infections organism or prevent them from causing infection [14].

The search for new biomaterial for advanced medical application is now an interest for scientists for whom a consistent interdisciplinary approach evolves. In the present study, antimicrobial Lenses were prepared by coating the Lens with modified Chitosan. Chitosan & its derivatives are biodegradable, biocompatible and non toxic polymer having film forming & coating property. The sulfooxyamine modified Chitosan is amorphous polymeric material and also permeable for oxygen and other gases therefore it will also be a suitable excipient for fabrication of contact Lenses. Due to the antimicrobial activity and mucoadhesive nature of Chitosan and its derivatives, it will be suitable polymeric candidate as a coating material to the Lenses. This research relates to the polymeric modification of Chitosan, their preparation by reacting Chitosan with Thionyl chloride and further with ammonia and their use as a coating material to the Lens. UV visible interference, Light transmittance & antimicrobial evaluation of coated Lenses were determined as compared to uncoated Lens [15].
2. MATERIALS AND METHODS

2.1 Materials

All synthetic chemicals were procured from local distributors and were of LOBA Chemie Pvt. Ltd, Mumbai, India. The microwave was used for synthesis of modification of Chitosan.

2.2 Modification of Chitosan

Modification was performed by our previous described method [14]. Chloro sulfoxyl Chitosan was synthesized by mixing the 100 ml of pyridine with 10 gm of Chitosan. To this, 8 ml thionyl chloride was added slowly with shaking. The reaction mixture was irradiated in microwave for 1 min and kept overnight for digestion. The solid product was filtered, washed with rectified spirit. Sulfoxyamine chitosan was prepared by stirring chloro sulfoxy Chitosan with 50 ml ethanol containing 10 ml ammonia for 3 hrs. The solid product was filtered, washed with rectified spirit and dry.

2.3 Characterization of Modified Chitosan [14-17]

2.3.1 Fourier transform infrared spectroscopy

FTIR spectral analysis of Chitosan & Poly Sulfoxyamine Grafted Chitosan was recorded on a BRUKAR FT-IR alpha ATR spectrometer.

2.3.2 Differential scanning calorimeter (DSC)

Differential Scanning Calorimetric thermogram of XG and MXG were recorded in the temperature range of 40°C – 300°C at a heating rate 10°C/min.

2.3.3 Elemental analysis

CHNO was determined by Thermo finnigan, FLASH EA 1112 series.

2.3.4 Oxygen analysis

Modified Chitosan was studied for Oxygen Analysis.

2.4 Coating of Ophthalmic Lenses

1 gm modified Chitosan dissolved in 100 ml distilled water. The ophthalmic Lenses were soaked in 1% w/v modified Chitosan solution for 5 min. Remove the lenses and dry it. This process was repeated for three times. Finally coated lenses were used for further evaluation.

2.5 Evaluation of Contact Lenses

2.5.1 UV-visible spectroscopy

Coated and uncoated Lenses were taken in 5 ml of normal saline solution. Lens was placed into cuvette and a scan wavelength from 200 nm to 800 nm. Absorption and transmittance were determined [16,17].

2.5.2 Antimicrobial evaluation

The bacterial (pseudomonas aeruginosa) and fungal (Candida albicans) strains were obtained from fresh cultures from Department of Microbiology, GIPER, Limb, Satara. The study was simultaneously performed for the uncoated ophthalmic Lenses. In brief, agar plates were prepared and sterilized in autoclave. The organisms were spread uniformly throughout the plate. Modified Chitosan coated Lens and control Lens was placed into the plate. The plate was kept for diffusion in refrigerator for 1-2 hrs and then plates were kept for incubation in incubator at 37°C for 12 and 24hrs respectively. Finally, the zone of inhibition was measured [18-20].

3. RESULTS AND DISCUSSION

The evidence from melting point (195-200 °C), FTIR and DSC revealed that compound is synthesized.

3.1 Fourier Transform Infrared Spectroscopy

FTIR Spectrum of chloro sulfoxyl chitosan showed all functional groups as that of Chitosan except amino group as shown in Fig. 1. FTIR Spectrum of Poly Sulfoxyamine Grafted Chitosan showed all functional group of chloro Sulfoxyl chitosan except amino group at 3302 – 3360 cm⁻¹ & it confirmed the replacement of Chloro group with amino as shown in Fig. 2.

In a Chitosan primary amine (RNH₂) showed broad signal at 3300-3300 cm⁻¹ with two sharp spikes but that two sharp spikes were absent in Chloro Sulfoxyl modified Chitosan which indicated that substitution occurred on that primary amine of Chitosan. The peak with two sharp spikes at 3365 cm⁻¹ in FTIR spectra of final compound indicated ammination once again occurred by replacing chlorine groups.
3.2 Differential Scanning Calorimetry (DSC)

Differential Scanning Calorimetric thermogram of chitosan and modified chitosan were recorded in the temperature range of 40°C – 300°C at a heating rate 10°C/min.

As per DSC curve (Fig. 3) of modified Chitosan showed a broad endothermic peak at about 89.11°C. In case of chitosan generally it will occurred at 65-70°C This endothermic peak, often termed as dehydration temperature (TD), is due to the evaporation of water associated with the hydrophilic groups of the polymers and responsible for the strength of water-polymer interaction.
Fig. 3. DSC of modified poly sulfoxyamine grafted chitosan

Fig. 4. Elemental analysis CHN of modified poly sulfoxyamine grafted chitosan
3.3 Elemental analysis CHNO of Modified Chitosan

The % of elements i.e. CHNO were determined by Thermo finnigan, FLASH EA 1112 series.

Elemental analysis is a process of determining what elements are present in the chemical compound or mass fractions of carbon, hydrogen, nitrogen and oxygen. This information is important to help determine the structure of unknown compounds as well as to help ascertain the structure and purity of synthesized product. Increase or decrease the % of elements indicates the modification of compound or polymer. The % of elements was found to be C: 35.078, H: 6.479, N: 6.421.

3.4 Oxygen Analysis Modified Chitosan

Modified Chitosan was also studied for Oxygen element and the % was O: 42.285%.

![Fig. 5. Oxygen analysis of modified poly sulfoxyamine grafted chitosan](image)

![Fig. 6. UV visible light absorption of uncoated lens and coated lenses](image)
3.5 UV-Visible Spectroscopy Evaluation of Contact Lenses

As per Fig. 6 Since eye protection from harmful UV radiation is an important issue, therefore UV absorption of modified Chitosan was determined and absorption of UV radiation was found to be at 256 nm. This indicated that coating material also absorbs harmful UV radiation and protect the eye.

The % light transmittance of the coated ophthalmic Lens was found to be same as that of uncoated Lens. These results indicated that addition of the modified Chitosan layer does not appreciably affect the % light transmittance of the contact Lens and therefore would not obstruct the patient vision.

Optical purity of the contact Lenses before and after treatment with modified Chitosan, % light transmittance readings over the wavelength range of 200-800 nm were obtained using Shimadzu spectrophotometer. However, only the visible range is necessary for comparing optical transmittance of contact Lenses. The uncoated and coated ophthalmic Lens was found to be same the ophthalmic purity/transferancy. The optical purity/transferancy of ophthalmic Lenses are as shown in Fig. 1. These results indicated that addition of the modified Chitosan layer does not appreciably affect the purity/transferancy of the contact Lens and thus would not obstruct the patient vision.

3.6 Antimicrobial Study of Contact Lenses

The antimicrobial study of ophthalmic Lens showed in Table 1. The results indicated that the coated Lenses with modified Chitosan inhibit the growth of bacteria and fungi as compared to control Lens as shown in Table 1.

The zone of inhibition of coated Lens was found to be 3.1 mm and 2.2 mm against Candida albicans and pseudomonas aeruginosa respectively. The control Lenses have no zone of inhibition.

<table>
<thead>
<tr>
<th>Antimicrobial strains</th>
<th>Coated lens</th>
<th>Control lens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Candida albicans</td>
<td>3.1</td>
<td>00</td>
</tr>
<tr>
<td>pseudomonas aeruginosa</td>
<td>2.2</td>
<td>00</td>
</tr>
</tbody>
</table>

Fig. 7. % of UV Visible light transmittance of uncoated Lens and coated Lens

Table 1. Zones of inhibition of coated & uncoated lenses
4. CONCLUSION

Contact lenses for ophthalmic drug delivery have become very popular, due to their unique advantages like extended wear and more than 50% bioavailability. Contact lenses are modern expansion in ocular drug delivery system. Due to the frequent use of contact Lenses, there is an increase the microbial load in the eye which can adversely affect to the corneal health. Microbial Keratitis & other microbial infection are serious complications of contact Lens wearer & can lead to serious impairment of vision. In view of this, if Lens are coated with modified Chitosan, which will reduce the microbial growth & microbial transmission from one surface to another. UV– visible spectroscopy results indicated that modified Chitosan material is not interference in the visible region & showed 100% transmission of visible light. This research reduces the patient extra effort of measure for microbial contamination but additional research is needed in this subject. So these developed Contact lenses are modern expansion in ocular drug delivery system and it will improve increase patient compliance.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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