NANOPARTICLE-LOADED HYDROGEL CONTACT LENS: A POTENTIAL OCULAR DRUG DELIVERY SYSTEM FOR A CONTROLLED RELEASE

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1. Introduction

Ocular drug delivery (ODD) represents a considerable challenge for drug delivery and formulation scientists. There are several routes for ODD [1] (**Figure 1**).

The development of novel nanoparticle (NP)-laden soft contact lenses (SCLs) is being investigated as a way to enhance controlled drug release and targeted delivery [2] (**Figure 2**).

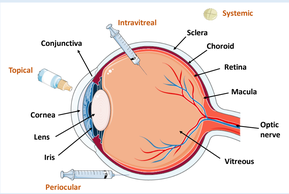


Figure 1: Ocular drug delivery routes [3].

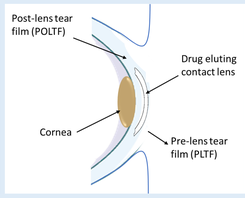


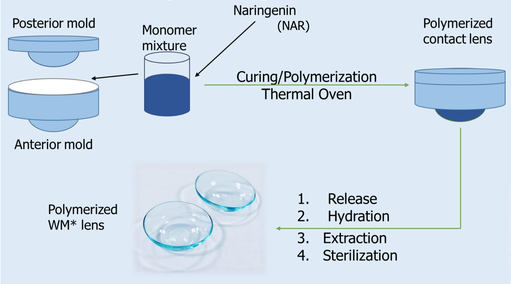
Figure 2: Ocular drug delivery through contact lens [4].

2. Key Aims

- To manufacture contact lenses that have comparable properties to commercial lens.
- To study polymerization kinetics and the effects of sterilization on lens properties.
- To formulate and optimize polymeric nanoparticles for drug encapsulation, followed by their incorporation into fabricated lenses.
- To formulate and optimize drug-loaded contact lenses.

3. Experimental Methodology

Manufacturing and Characterization of Contact Lenses

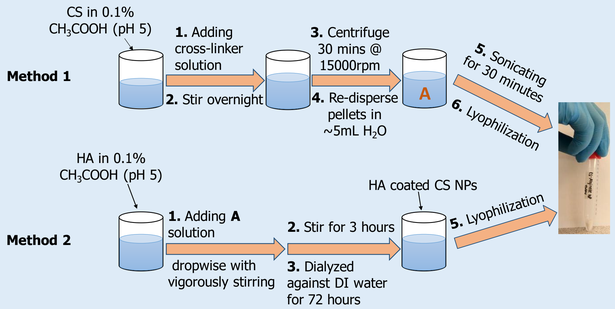


Chemical properties
Equilibrium water content
Optical transparency
Refractive index
Ionic permeability

Physical properties
Wettability
Morphology
Tensile strength
Tribology

Dimensional tests
Diameter, center thickness, saggital depth, roundness
Power
Edge profile

Synthesis of Nanoparticles



*CS: Chitosan
**HA: Hyaluronic acid

4. Results and Discussion

Characterization of Contact Lenses

Table 1: Lens dimensions, power and refractive index (n = 10).

Sample	Diameter (mm)	Sag (mm)	Roundness (mm)	Power (D)	Refractive index
WM lens	14.33 ± 0.07	3.98 ± 0.04	0.22 ± 0.11	-2.83 ± 0.07	1.3733 ± 0.0002
Control lens	14.20 ± 0.20	3.82 ± 0.10	< 0.4	-3.00 ± 0.25	1.3742 ± 0.0003

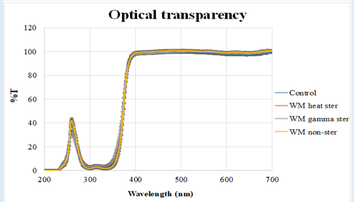


Figure 3: Optical transparency for control lens vs WM lens after different sterilization processes (n = 3), indicated that all 4 lens types reached >99% light transmittance.

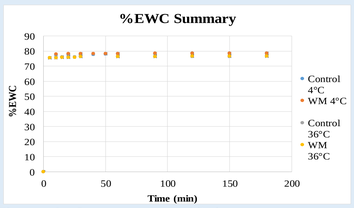


Figure 4: Percentage equilibrium water content for control lens versus WM lens at two different temperatures (n = 3), showed that the tested hydrogels equilibrated extremely fast (after 5-10 minutes).

Characterization of NAR:Cyclodextrin Complexes

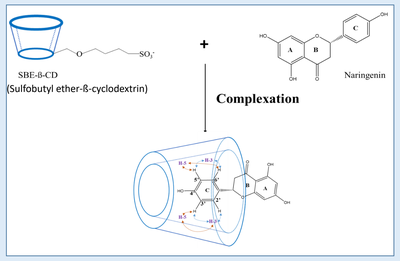


Figure 5: Proposed schematic diagram on the possible inclusion mode of NAR and CD [5].

- The optimum NAR:CD concentration ratio was studied to be 1:3.
- Freeze-drying of tert-butyl alcohol:water co-solvent system is the best approach in the preparation of the complex.
- Complexation efficiency of NAR in the complex was determined to be 98.7±0.8%.
- A significant increase of 6481-fold in NAR aqueous solubility upon forming a complex with CD was found, from 0.0005 mg/mL to 3.24 mg/mL.

Characterization of Nanoparticles

Table 2: Particle size, charge and polydispersity index for developed NPs.

Samples (n = 3)	Average size (nm)	Zeta potential (mV)	PDI (polydispersity index)
CS NP	360.0 ± 9.9	+38.6 ± 2.1	0.0671 ± 0.0362
NAR-loaded CS NP	333.3 ± 26.6	+22.0 ± 4.3	0.0777 ± 0.0580
HA coated CS NP	366.3 ± 27.7	-28.6 ± 1.1	0.1212 ± 0.0216

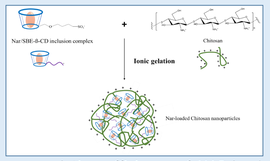


Figure 6: NAR encapsulation efficiency of NAR-loaded CS NPs was determined to be 13.0 ± 1.9% (n = 3).

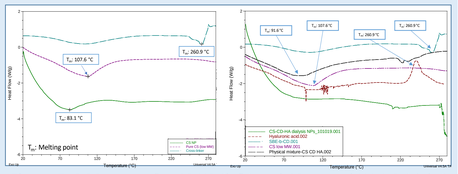


Figure 7: DSC curves for CS NP (left) and CS coated HA NP (right).

- A change in T_m of CS of synthesized NP implied the formation of CS NP after cross-linking.
- The developed NPs are thermally stable up to 250 °C as there was no degradation observed.

5. Key Findings

- Lenses were successfully manufactured on-site, which exhibited all the critical parameters when compared to the commercially prepared lens.
- HA-coated CS NPs were shown to enhance the stability of CS NPs at pH 6.8-7.4.
- A significant increase of 6480-fold in NAR aqueous solubility by forming a NAR:CD complex.

6. Future Work

- Formulation and characterization of NP-loaded contact lenses.
- Drug release profiles of the developed drug-loaded NPs and NP-loaded lenses.
- Cell-based studies investigating drug-loaded NP: cytotoxicity, anti-inflammatory, anti-oxidant and mucoadhesion.

7. References

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