Drug Entrapment Efficiency of Silver Nanocomposite Hydrogel

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Abstract: Silver nanocomposite hydrogel (SNH) with biodegradable polymers, sodium alginate and sodium lignosulphonate was synthesized employing principles of green chemistry for possible application in the field of controlled drug release. One of the factor that determines the release of drug from blend is the quantity of drug present/trapped inside the polymer network. The entrapment of drug in the polymer matrix depends upon the stability of matrix and interaction between the drug and the matrix. In the present study effect of presence silver nanoparticles in the polymeric matrix on the Drug Entrapment Efficiency (DEE) for the drug ciprofloxacin (CPX) was investigated. The drug entrapment efficiency for CPX loaded beads of SA/LS was calculated for similar conditions, to evaluate the effect of silver nanoparticles. Experimental results confirmed role of crosslinking and presence of silver nanoparticles on the stability of SNH and its entrapment efficiency. Observations indicate that the drug entrapment is more for the SNH as compared to the blend. Presence of silver nanoparticles help stabilize the polymer matrix, improves binding inside the matrix, which leads to the better drug entrapment.

Keywords: Sodium alginate, Lignosulphonic acid, Drug entrapment, Control release.

1. Introduction

Alginate, a naturally available anionic and hydrophilic polysaccharide, is synthesized abundantly in nature [1]. Its structure includes blocks of β-D-mannuronic acid and α-L-guluronic acid monomers arranged alternatively. Alginates are biocompatible, biodegradable, and possess chelating ability. They are used in a broad range of applications such as biomaterial and especially as the supporting matrix or delivery system for tissue repair and regeneration[2-3]. Sodium alginate (SA) blends with other suitable polymers have been widely investigated for drug delivery applications [4-5]. Drug formulations for ocular, oral intravenous and subcutaneous administration are microencapsulated to achieve targeted, controlled or triggered release of active ingredients. Encapsulation allows controlled release of drug for its effective use, reduces overdose related toxicity and dosing frequency [6-8]. It is a known fact that in a matrix type capsules, drug gets distributed uniformly throughout the polymeric matrix which is then released slowly by the swelling and erosion of the matrix under suitable condition. The drug release from matrix-type tablets is first order, in which the release rate decreases exponentially with time until the active ingredient is exhausted. Studies have shown that presence of silver nanoparticles in the blend matrix has shown stability of polymer matrix [9] and better control over the retention and release of drug [10]. Silver nanoparticles are known for antibacterial properties and their presence in hydrogel will have an added advantage.

In our previous research we have investigated the suitability of SA blend with lignosulphonic acid (LS), a polymer from plant for drug delivery applications [11]. In an attempt to improve the stability and drug release property of SA/LS blend prepared earlier, we developed a Silver Nano Hydrogel (SNH) by incorporating silver nanoparticles stabilized in LS matrix into the SA matrix followed by crosslinking with calcium chloride. In this polymeric material, CPX, as a model drug was loaded for controlled release study. The focus of this article is to explore the effect of AgNP on drug entrapment efficiency (DEE) an
important aspect in drug release study. Drug Encapsulation efficiency (DEE) is the percentage of drug incorporated into the polymeric material (bead) compared to the total amount of the drug present during encapsulation process.

2. Chemicals and Methods

2.1. Chemicals
Sodium alginate and Lignosulphonate are purchased from Sigma Aldrich, Germany and Calcium chloride from Nice chemicals, India and Ciprofloxacin drug received as a gift sample. All the chemicals are used as received. Distilled water is used to prepare all solutions.

2.2. Preparation of Silver nanocomposites and SA/LS blends
To 20 mL of 20% LS solution, 5mL of 1% silver nitrate solution was added and heated in microwave oven at 300W power for 2 min. To this 25 mL of 80% aqueous solution of SA and 2.5% CPX of total blend was added. The hydrogel was achieved by mixing them with constant stirring for 30 min on a magnetic stirrer. The SA/LS blends are prepared in the proportion of 80/20 by solution casting method and to this mixture 2.5% of CPX drug is added [12].

2.3. Preparation of Beads
Beads were prepared by dropping CPX loaded SNH solution from a syringe at the rate of 60 beads/min into a beaker containing 50mL of 2% Calcium chloride solution. The beads were allowed to crosslink for 30 mins. The beads were then taken out, washed with distilled water and dried in hot air oven for 24 hrs at 60°C.

2.4. Measurement of Drug concentration by UV-Vis Spectrophotometer
The total amount of drug released while crosslinking in 50mL of CaCl₂ solution and drug release from beads in 50mL pH 7 solution for 24 hrs was measured by UV Visible spectra. The UV-Vis spectra are recorded over the range of 250–600nm at a resolution of 1 nm with Schimadzu 2600 UV-Vis spectrophotometer.

2.5. Calculation of Drug Entrapment Efficiency
DEE is calculated from the formula given below:

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\text{DEE} = \frac{(\text{Total Drug conc.} - \text{Supernatant Drug conc.})}{(\text{Total Drug conc.})} \times 100% \quad (1)
\]

The values for the drug concentrations of 30 minute crosslinked beads were obtained from the UV Visible spectra. DEE was calculated for each one of them separately.

3. Results and Discussions

Drug Entrapment efficiency (DEE)
Beads of CPX loaded SA/LS blend or SNH is achieved by ionotropic gelation method by dropping the hydrogels into calcium chloride solution for 30 mins. Droplets instantaneously formed gelled, spherical beads due to crosslinking of calcium ion with the alginate ion. Formation of calcium alginate enables encapsulation of CPX into the matrix. During the process, part of the drug which is loosely bound in the drug matrix is lost in the calcium chloride solution. By observing the UV Visible spectra of the CaCl₂ supernatants obtained after crosslinking, the drug amount lost can be calculated from a calibration curve. A calibration curve is achieved by plotting the absorbance of the drug solution containing different amount of CPX against the drug concentration. Fig. 1 shows the calibration curve of CPX solution at different concentrations which follows Beer Lamberts law.
The amount of CPX present in SNH and SA/LS beads is obtained by taking the UV-Vis spectra of the solution obtained after complete dissolution of their beads in 24 hours. The spectra observed are shown in Figure 2.

These graphs indicate that the drug entrapment for the SNH is higher than the SA/LS beads. The absorbance values for each curve were used to calculate the DEE using equation 1. The DEE for SA/LS is 49% while for SNH is 58.7%. Nanoparticles during their formation and stabilization get attached to the functional groups present on polymer chain [Figure 3b]. This increases the stability of the polymeric matrix. A stable matrix holds the drug molecule more efficiently and prevents its release from matrix into the CaCl₂ solution during the gelation process. The stability of the SNH matrix is also evident from the stability of beads in pH7 solution for 6 hrs as compared to SA/LS beads which degrades in 3 hrs [Fig 4].

4. Conclusion

Microsphere of SNH and SA/LS blends were prepared by ionotropic gelation method and the effect of silver nanoparticles on the drug entrapment was investigated. Study indicates that more drug is lost from the matrix during bead formation for the SA/LS. Presence of silver nanoparticles has improved the entrapment of drug. The silver nano hydrogel can be effectively used for entrapment and control release of drugs.
5. References

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