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# Novel chitosan/PVA@hyaluronic acid and chitosan/PVA@hyaluronic acid/curcumin films for wound healing

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## ABSTRACT

Wounds disrupt the proper function of the skin, and the use of biocompatible films ensures the right conditions for wound healing, prevents microbial infection and thus leads to skin regeneration. Chitosan (CS) is a natural polymer with healing properties and in combination with polyvinyl alcohol (PVA) - a synthetic, biocompatible polymer - its mechanical properties are enhanced. In this study, the films are based on biocompatible hydrogels that are produced via the action of hyaluronic acid (HA) as a natural cross-linker, and the interactions between the polymeric chains of CS, PVA and HA. The incorporation of curcumin (Cur), which is a natural antimicrobial agent, ensures protection of the wound against pathogenic microbes. Generally, the aim of this study is to examine the impact of varying cross-linker concentrations on the films. Thus, two groups of films were prepared: PVA/CS/HA and PVA/CS/HA/Cur, with varying concentration of HA (0.5, 1, 2, 2, 3 % w/w) and fixed concentration of PVA (1% w/v), CS (2% w/v) and Cur (0.1% w/w) (Figure 1). The characteristic peaks of the films in FTIR appear to be slightly shifted which confirms the crosslinking between the chains (Figure 2), while XRD is included (Figure 3). Moreover, swelling (Figure 4) and stability (Figure 5) assays proved that PVA/CS/HA and PVA/CS/HA/Cur containing 2% w/w HA exhibited optimal behavior under conditions of injured skin.

## EXPERIMENTAL PROCEDURES

**Synthesis:** PVA (1% w/v) was dissolved in hot deionized water at 80 °C and after the temperature was reduced to 35° C, the respective amount of sodium hyaluronate (0.5, 1, 2, 3 % w/w) was added, followed by the addition of CS (2% w/v). Acetic acid was added dropwise to a final concentration of 1% v/v and stirring was continued until complete homogenization of the hydrogel. For the PVA/CS/HA/Cur films the same procedure was followed. After the addition of CS, Cur was dissolved in 10 ml of acetone and the Cur solution was added to the PVA/CS/HA solution. The PVA/CS/HA/Curc solution was put under mechanical strong stirring and acetic acid was added dropwise to a final concentration of 1% v/v 50 ml of each hydrogel was placed in a petri dish and dried under vacuum at 38° C.

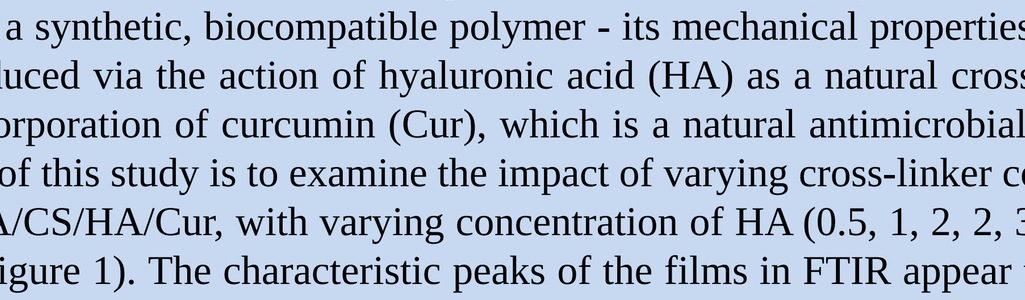


**Figure 1.** PVA/CS/HA (left) and PVA/CS/HA/Cur (right) films.

## RESULTS

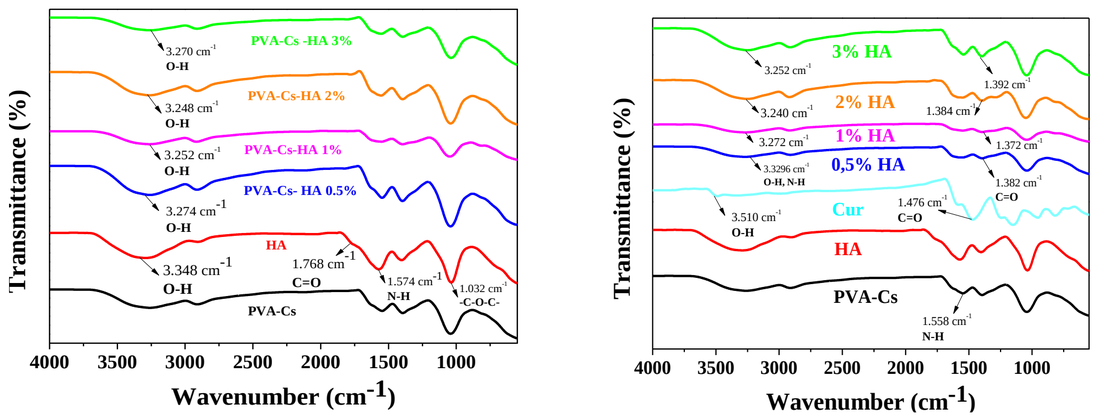


**Figure 2.** FTIR spectra of PVA/CS/HA (left) and PVA/CS/HA/Cur (right) films.

All films show similar peaks compared to PVA/CS films and HA. The band between 3.500-3.300 $cm^{-1}$ is found in all HA-containing films, however it is lightly shifted, due to the to the hydrogen bond formation between the polymers. The lower band intensity of 1.768-1.574 $cm^{-1}$ in the PVA/CS/HA also confirms the interactions. Hydrogen bonds between the ketone groups of curcumin and the remaining free groups increase the C=O bond resulting in a shift of the peaks in the spectra of PVA/CS/HA/Cur films.

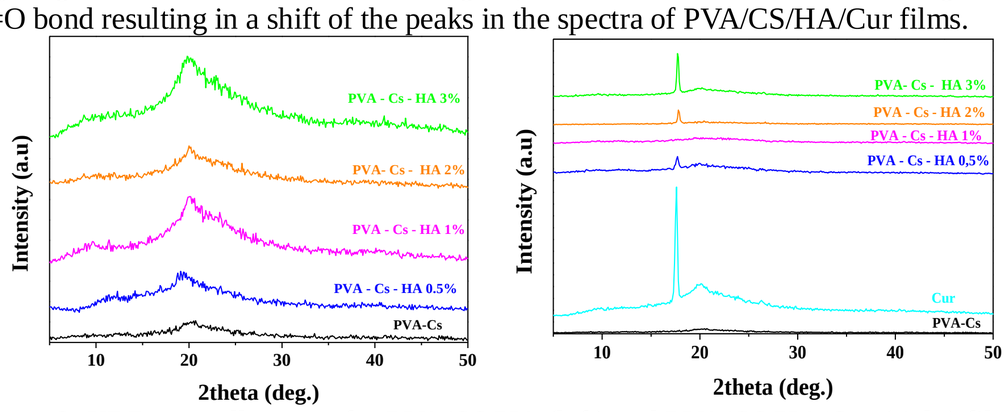


**Figure 3.** XRD crystallograms for PVA/CS/HA (left) and PVA/CS/HA/Cur (right) films.

As the concentration of HA increases, the intensity of the peak at 20° decreases, as the crystallinity of the films decreases due to the interactions between PVA, CS, HA and Cur. In the PVA/CS/HA/Cur the peak at 18° is decreased, indicating the successful encapsulation of Cur.

## DISCUSSION

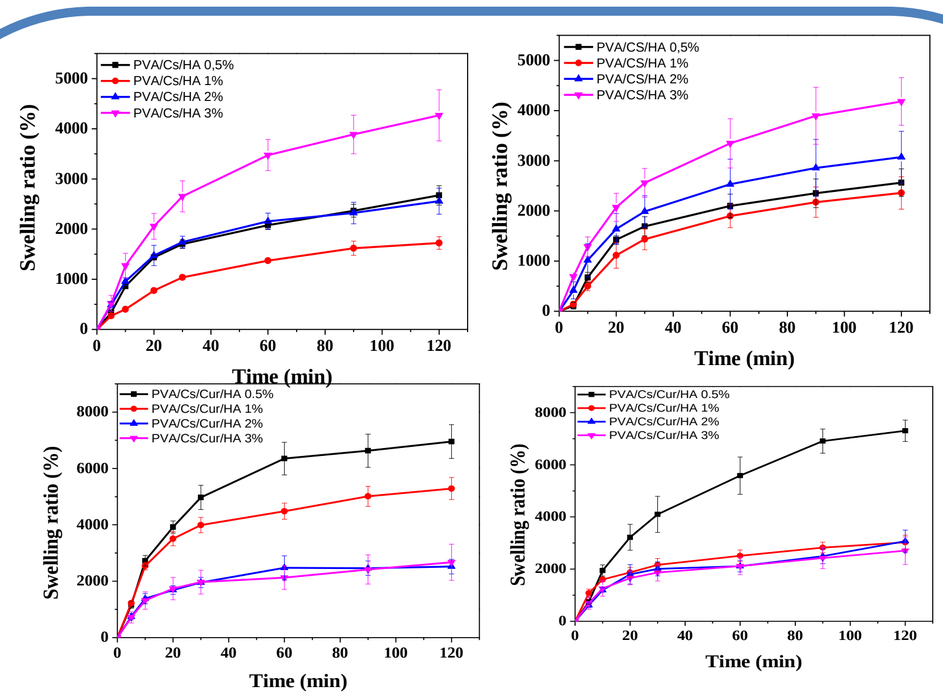


**Figure 4.** Swelling assay of PVA/CS/HA films (up) and PVA/CS/HA/Cur films (down) at pH 5.68 (left) and 7.48 (right).

The study examines the behavior of PVA/CS/HA membranes under different pH conditions, highlighting their properties and degradation patterns. At pH 5.68 (injured skin), membranes retain more solution but degrade faster than at pH 7.48 (healthy skin). Adding chitosan (CS) and hyaluronic acid (HA) slows degradation compared to membranes with only PVA and HA, due to HA's cross-linking ability. However, HA's hydrophilic nature accelerates hydration and degradation as its concentration increases. Higher HA levels reduce water retention because increased cross-linking creates a denser polymer mesh with smaller pores. Curcumin further enhances membrane stability by acting as an additional cross-linker.

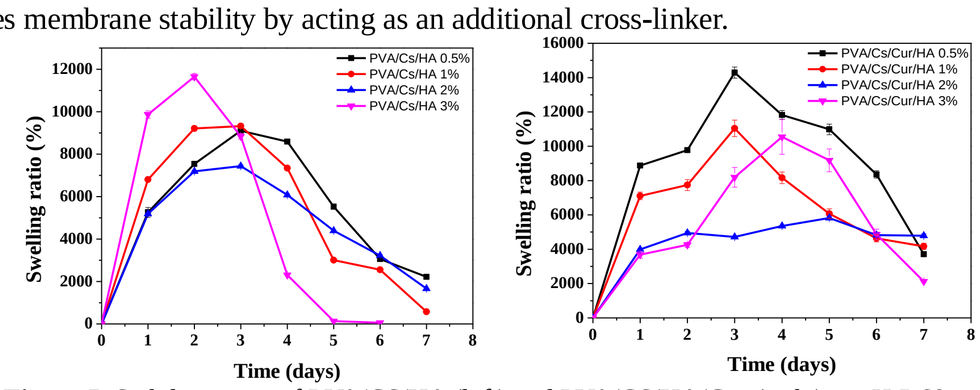


**Figure 5.** Stability assay of PVA/CS/HA (left) and PVA/CS/HA/Cur (right) at pH 5.68.

## CONCLUSIONS

- FT-IR results confirmed the interactions between PVA, HA, Cs and Cur via hydrogen bonds between their hydroxyl groups, amino groups or keto-groups.
- At pH = 5.68 (injured skin) the films retain a greater amount of buffer, but degrade more rapidly than under pH = 7.48 (healthy skin) conditions
- Due to the highly hydrophilic nature of HA, as its concentration increases, its solvent binding ability is enhanced and thus films with increased HA concentration degrade faster.
- The addition of HA increases the stability of the films due to its role as a cross-linker.
- Increasing HA concentration in PVA/CS/HA/Cur films decreases the water retention capacity.
- The addition of curcumin increases the stability of PVA/CS/HA/Cur films compared to PVA/CS/HA films, which is explained by its potential to act as a cross-linker.
- 2% w/w HA containing films exhibited optimal behavior under conditions of injured skin.

## REFERENCES

1. Pan, N.C.; Bersaneti, G.T.; Mali, S.; Celligoi, M.A.P.C. Films Based on Blends of Polyvinyl Alcohol and Microbial Hyaluronic Acid. *Braz. arch. biol. technol.* 2020, *63*, e20190386, doi:10.1590/1678-4324-2020190386.
2. Xu, H.; Ma, L.; Shi, H.; Gao, C.; Han, C. Chitosan–Hyaluronic Acid Hybrid Film as a Novel Wound Dressing: *In Vitro* and *in Vivo* Studies. *Polymers for Advanced Techs* 2007, *18*, 869–875, doi:10.1002/pat.906.