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Vanillin cross-linked chitosan/PVA membranes loaded by dexpanthenol for skin tissue regeneration

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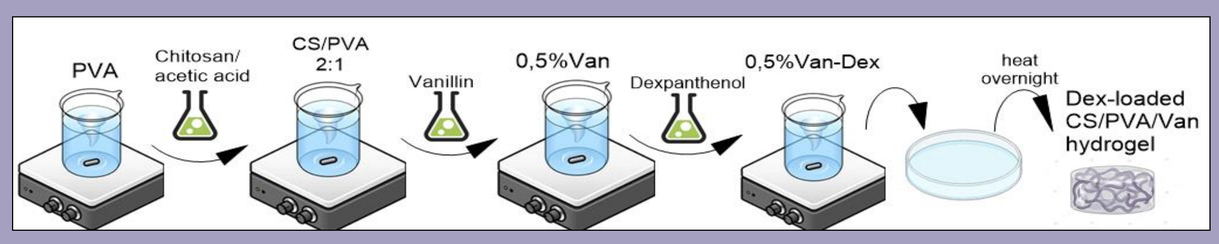
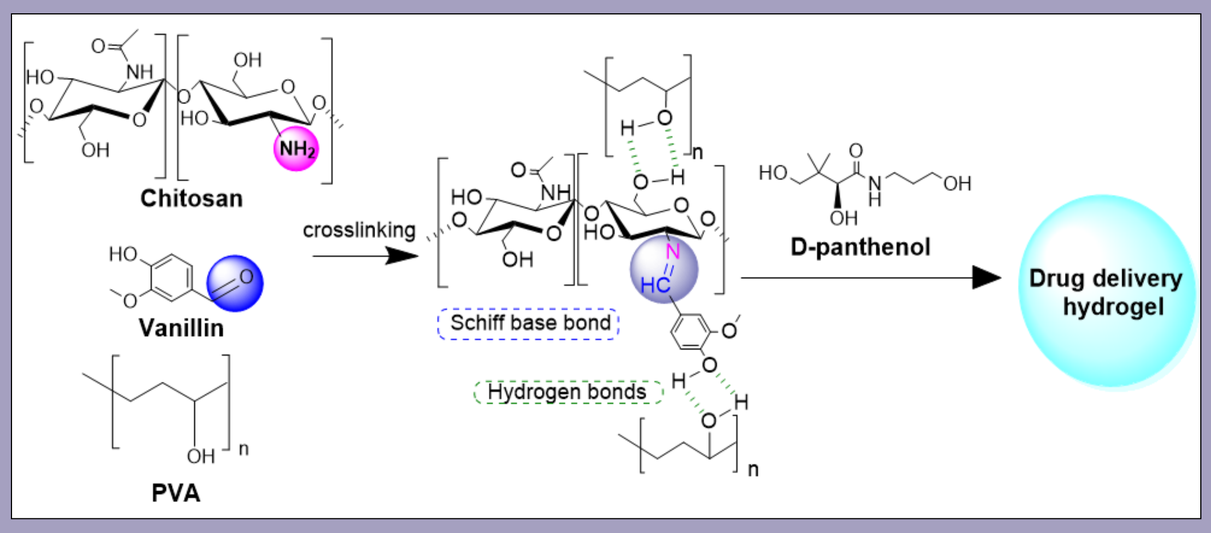
1. INTRODUCTION

The development of a patch that can both prevent wound infection and facilitate tissue remodeling is crucial for effective wound healing. This study focuses on creating a series of skin-repairing dressings made from dexpanthenol (Dex)-loaded polymer membranes. These membranes are fabricated using chitosan (CS) and polyvinyl alcohol (PVA), crosslinked with vanillin (Van).The synthesis of these CS/PVA/Van-Dex wound dressings was characterized using Fourier Transform Infrared Spectroscopy (FTIR) to confirm their chemical composition. Their crystallinity was analyzed by X-Ray Diffraction (XRD). Additionally, we investigated the water sorption (WS) capacity and stability of the dressings under different pH conditions. The encapsulation efficiency and release rate of Dex from the prepared dressings were studied using UV-visible spectroscopy.The results from these analyses will provide insights into the potential of these dressings for improving wound care and promoting effective healing.

2. EXPERIMENTAL



3. CROSSLINKING MECHANISM



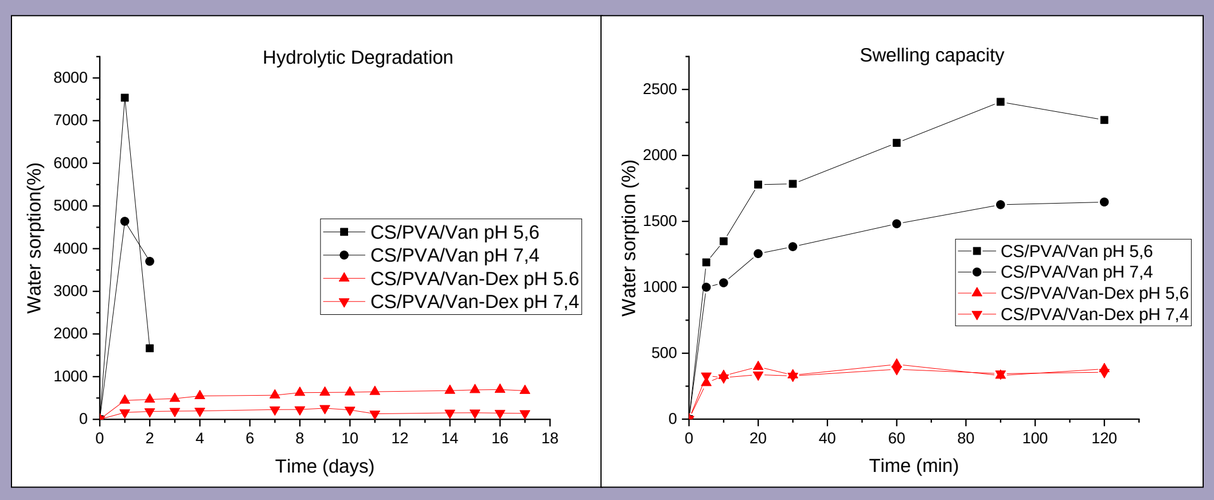


Figure 1. Water sorption capacity and stability of CS/PVA/Van and CS/PVA/Van-Dex

Water sorption capacity and stability

- The materials were tested at pH levels of 5.6 and 7.4 to evaluate their behavior in both healthy and wounded environments, respectively.
- The addition of Dex to the hydrogel network significantly enhanced the stability at both pH levels. The Dex-loaded dressings demonstrated a prolonged preservation time, lasting 15 days longer than the CS/PVA/Van samples.
- For CS/PVA/Van-Dex, the maximum water sorption was observed on day 15 with a WS capacity of approximately 697%. Dex exhibits stability in neutral to slightly acidic aqueous solutions (pH 4-6) but is less stable in highly acidic or alkaline environments. Consequently, at wound pH levels, the samples are more resistant to degradation.
- In the case of CS/PVA/Van films, higher WS was observed at pH 5.6 compared to pH 7.4. The Schiff base bond is stable at pH 7.4 and in alkaline solutions, but it loses stability in acidic environments.

4. RESULTS

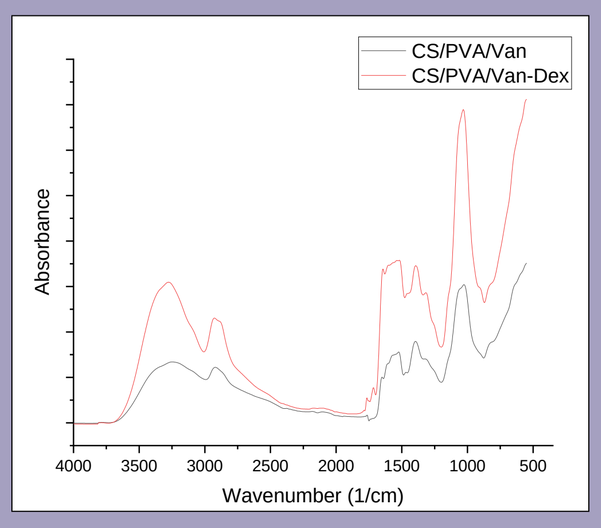


Figure 2. FTIR diagram of CS/PVA/Van, CS/PVA/Van-Dex

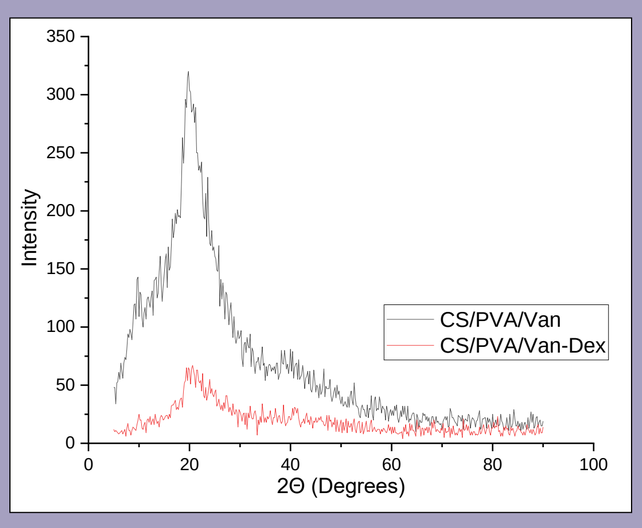


Figure 3. X-ray diffraction diagram

Structure characterization

The peaks observed in the Dex crosslinked network generally show slight shifts compared to the CS/PVA/Van samples, suggesting the hydrogen bonding of Dex with the other molecules.

3276 cm^{-1} ->3250 cm^{-1} O-H and N-H stretching vibration
2928 cm^{-1} Alkyl groups stretching vibration
1643 cm^{-1} Schiff base bond vibration
1520 cm^{-1} Amide II band vibration

Crystallinity study

CS and PVA typically exhibit semi-crystalline and crystalline domains. Their combination leads to interaction of –OH groups of PVA and the –NH groups of CS reducing the crystallinity and forming of an amorphous structure that is conducive to drug encapsulation. Dex and Van also contribute to the disruption of the crystalline domains.

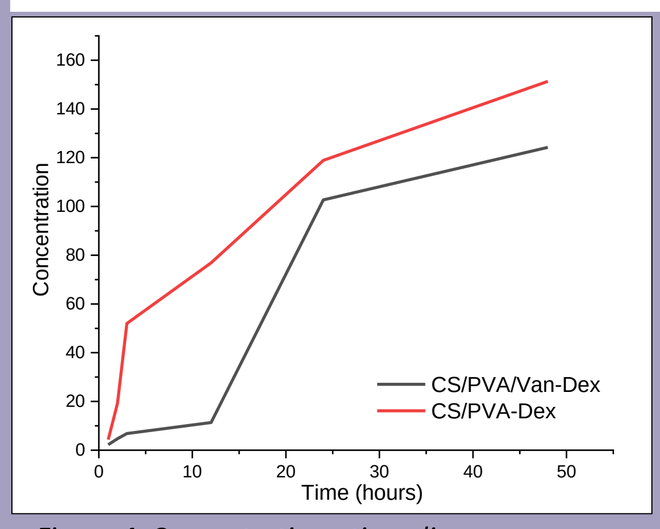


Figure 4. Concentration - time diagram

Release Study

The inclusion of Van increases the crosslinking degree of the polymer network, thereby slowing down the release of Dex. This effect is due to the synthesis of a more compact structure through crosslinking interactions. Additionally, Van introduces hydrophobic characteristics to the matrix, which reduces its water sorption capacity. Consequently, the drug release is decelerated in systems containing Van compared to those without it.

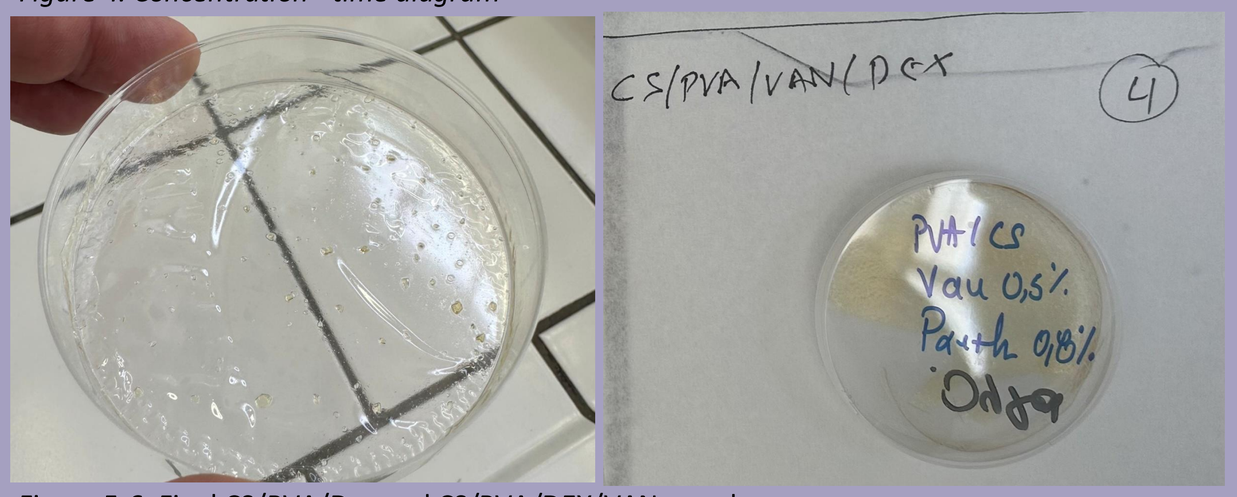


Figure 5-6. Final CS/PVA/Dex and CS/PVA/DEX/VAN membrane

5. CONCLUSIONS

In this study, skin-repairing dressings were prepared by incorporating Dex into CS/PVA polymer membranes crosslinked with Van. FTIR confirmed the successful incorporation of Dex into CS/PVA/Van dressings. The investigation into the WS capacity and stability of the dressings across different pH levels demonstrated that adding Dex significantly enhanced stability, particularly at wound-relevant pH levels. The release rate study of Dex revealed that the presence of Van decreased the released Dex concentration due to the formed polymer crosslinked network. Overall, the CS/PVA/Van-Dex dressings show promise as effective wound care materials, offering enhanced stability, satisfying drug release rate, and improved water sorption properties.