Development of a novel composite hydrogel as a material used in topical wound dressing

Arunwat Guntakam and Patnarin Worajittiphon

Department of Chemistry, Faculty of Science, Chiang Mai University, Chaing Mai 50200, Thailand

E-mail: patnarin.w@cmu.ac.th

Abstract

Carboxymethylcellulose sodium (CMC) is a highly water-soluble anionic polymer that appears as a white, odorless solid. It is biologically safe and acts as an effective water-retaining agent, demonstrating potential for application as a wound dressing. However, forming CMC into wound dressing films presents several limitations because the material is hard, brittle, difficult to shape, and lacks mechanical flexibility. To overcome the brittleness and lack of mechanical flexibility of the base polymer (CMC), this study incorporated poly(vinyl alcohol) (PVA) to improve the mechanical properties of CMC by determining the optimal amount of PVA. Citric acid (CA) was also added to serve as a cross-linking agent to enhance stability and prevent the material from dissolving in water during testing or application. The results showed that the optimal mixing ratio provided the material with good mechanical properties, making it easy to form into non-brittle films. Furthermore, the drug release capability was modified by adding anionic clay (AC) and layered material (LM) in various proportions to create composite hydrogel sheets. This study analyzed the physical, chemical, and morphological properties, revealing that the developed composite hydrogel sheets exhibited effective swelling performance as well as the ability to absorb and release a simulated drug. The experimental results indicate the feasibility of applying these composite hydrogel sheets as wound dressings.

Introduction



This research focuses on developing composite hydrogel films for wound dressings by addressing the inherent brittleness of sodium carboxymethyl cellulose (CMC). To enhance mechanical flexibility and structural stability, poly(vinyl alcohol) (PVA) and citric acid (CA) are incorporated as a film-forming agent and a crosslinking agent, respectively. Furthermore, anionic clay (AC) and layered material (LM) are added to optimize the film's physical and chemical properties. The study evaluates these materials to achieve a composite hydrogel with superior swelling capacity, improved drug release, and mechanical strength suitable for medical applications.

Methodology

- **Preparation of composite hydrogel**



Results and discusion

- **Sample characterization results**

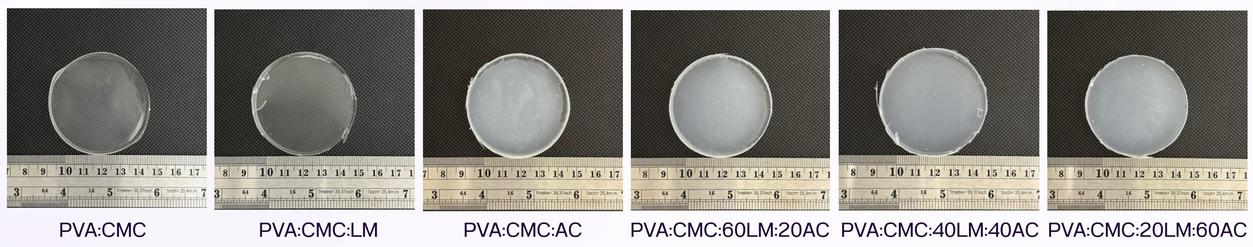


Figure 1. Physical appearance of different composite hydrogel films.

- **Surface characteristics of hydrogel composite films observed using scanning electron microscopy (SEM)**

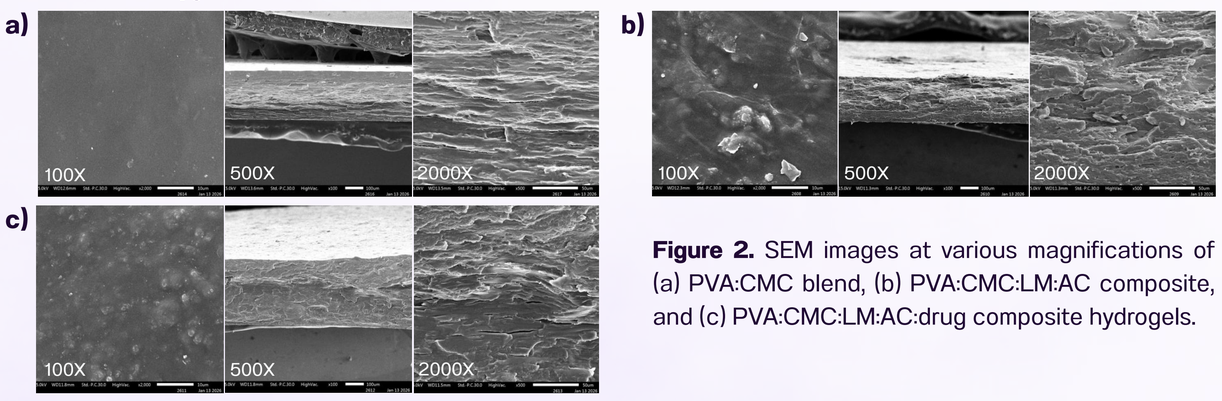


Figure 2. SEM images at various magnifications of (a) PVA:CMC blend, (b) PVA:CMC:LM:AC composite, and (c) PVA:CMC:LM:AC:drug composite hydrogels.

- **Morphology of hydrogel additives observed using transmission electron microscopy (TEM)**

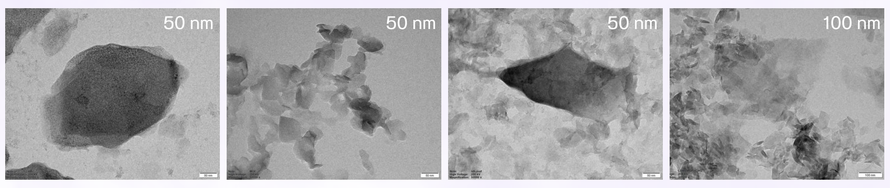


Figure 3. TEM images of different hydrogel additives.

- **Characteristics of hydrogels and their components studied by FT-IR spectroscopy**

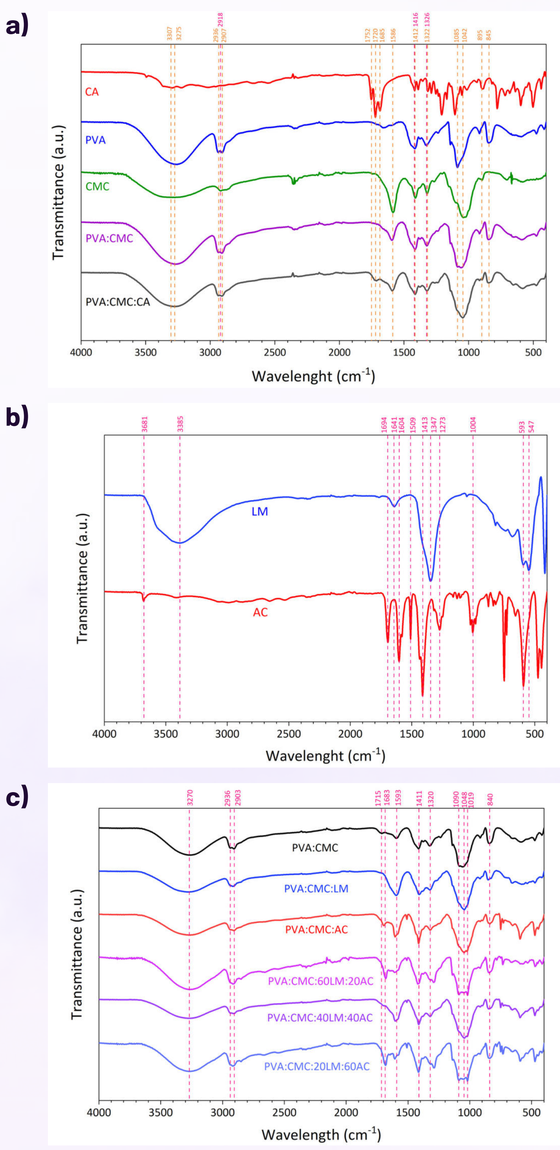


Figure 4. FT-IR spectra of (a) hydrogels, (b) hydrogel additives, and (c) composite hydrogels.

- **Swelling, drug loading, and drug release properties of vasious hydrogels**

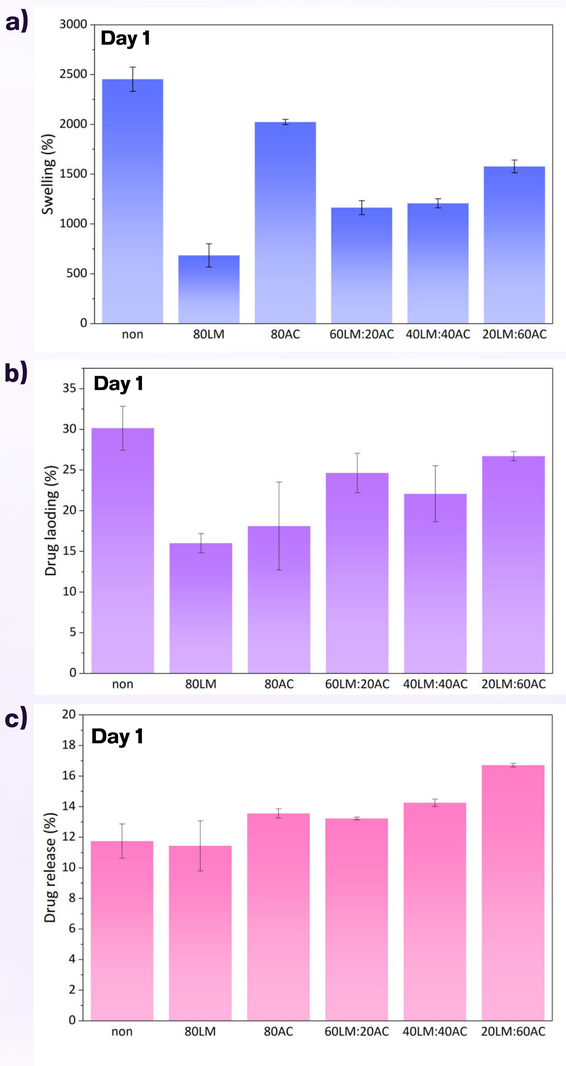


Figure 5. (a) Swelling, (b) drug loading, and (c) drug release of hydrogels and composite hydrogels with different compositions.

Conclusions

- The 50:50 CMC:PVA ratio was selected for desired film-forming and mechanical properties.
- The effect of different AC:LM proportions on drug release behavior was investigated.
- The 20:60 (AC:LM) ratio yielded the highest drug release in PBS (pH 7.4).
- The composite hydrogel films demonstrated their potential for wound dressing applications.

Acknowledgments

- Department of Chemistry, Faculty of Sceince, Chiang Mai University
- Faculty of Sceince, Chiang Mai University
- Polymer Research Laboratory, Faculty of Sceince, Chiang Mai University
- Dr. Thanaphorn Rakkan and Dr. Tharntrip Krasian

References

1. Barkhordari S, Alizadeh A. *Int. J. Biol. Macromol.* 260 (2024) 129486.
2. Rakkan T, et al. *Int. J. Biol. Macromol.* 330 (2025) 139417.
3. Kanthiya T, et al. *Sci. Rep.* 13 (2023) 13264.
4. Wilpiszewska K, et al. *J. Polym. Environ.* 27 (2019) 1379–87.
5. Elashmawi IS, et al. *Polym. Bull.* 80 (2023) 11379–99.