Hydrogel patches: A Soothing Solution

Natural hydrogel patches with antimicrobial, anti-itch and moisturising properties as an alternative to Wet Wrap Therapy for Atopic Dermatitis

Victoria Babajide, Prathamm Surana, & Chandrashekhar Kulkarni*
School of Pharmacy and Biomedical Sciences, University of Central Lancashire, Preston, Lancashire, UK.

Background

Atopic Dermatitis (AD), also known as eczema, is a chronic inflammatory skin condition characterised by **itching, dry skin**, and compromised barrier function.
The pathophysiology of AD involves a combination of genetic factors (such as mutations in the **filaggrin gene**), immune dysregulation, and environmental triggers; leading to immune activation, **disruption of the skin barrier, and increased susceptibility to infections**.
Patients experience significant discomfort from the **itch-scratch cycle,** and the constant skin irritation makes healing difficult.
Treatments often focus on maintaining moisture, reducing inflammation, and preventing infections.

Source: Stock image

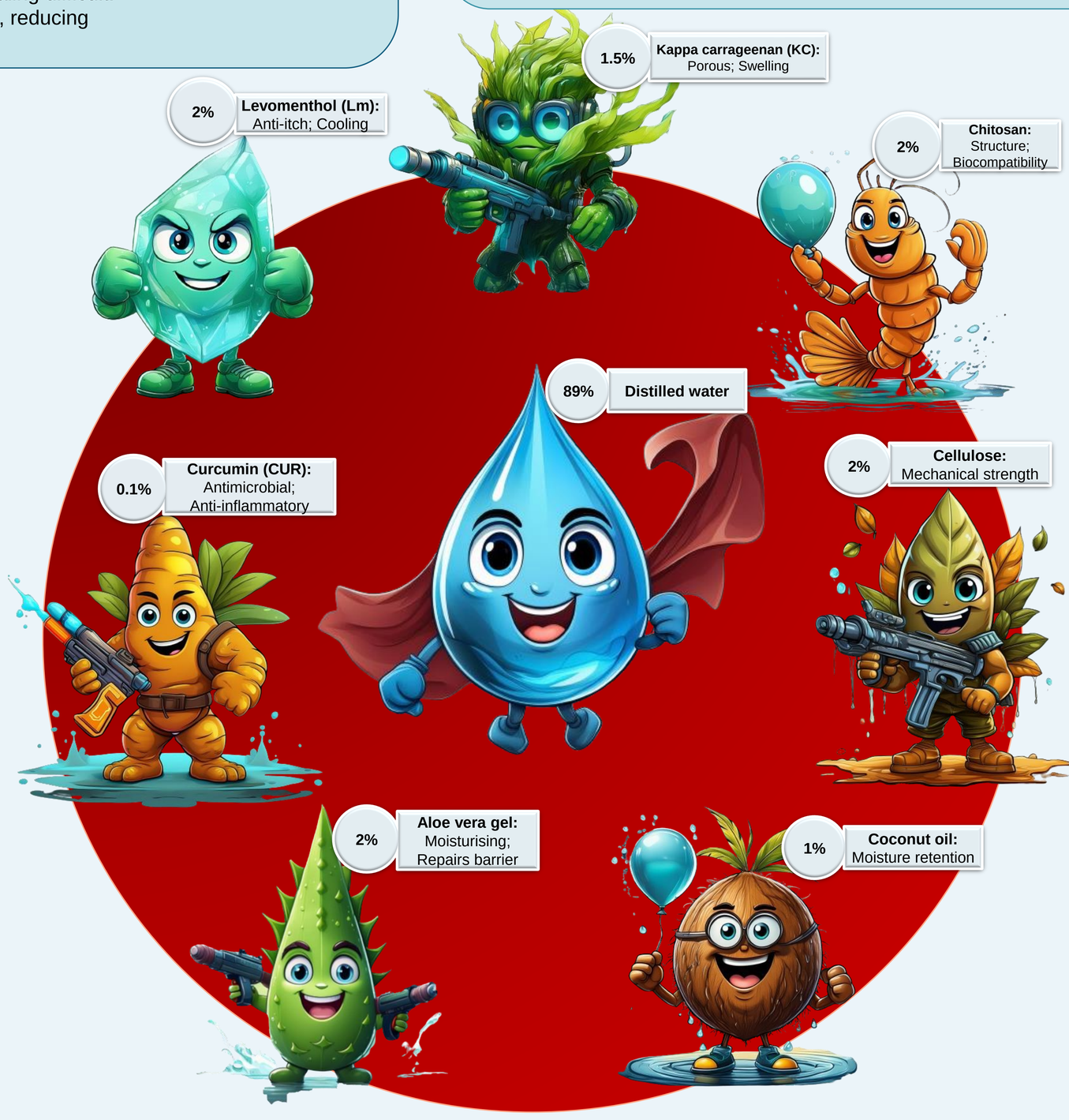
Atopic dermatitis (AD), flare-up on arm

Methodology

Hydrogels were prepared by mixing **natural compounds** and then cast into moulds to analyse their physical, chemical, and antimicrobial properties.
- **FT-IR Spectroscopy**: Assessed functional groups, molecular interactions, and active ingredient stability.
- **Differential Scanning Calorimetry (DSC)**: Evaluated thermal transitions and molecular stability.
- **UV-Vis Spectroscopy**: Monitored drug release kinetics.
- **Swelling Studies**: Measured water-holding capacity across different pH levels.
- **Scanning Electron Microscopy (SEM)**: Visualised the hydrogel's structure and texture.
- **Antimicrobial Testing**: Well-diffusion assays on *Staphylococcus aureus* were conducted.
- **Physical Characterisation**: Hydrogels were evaluated for weight variation, thickness, pH and appearance.

Advantages of our hydrogels:

- ✓ Hydration and moisture retention which helps repair the skin barrier and prevent further damage.
- ✓ Could be kept on the skin for up to 48 hours.
- ✓ Addition of antimicrobial components limiting infection risk.
- ✓ Adheres to the skin with a sticky border (similar to a plaster/dressing).
- ✓ Minimal loss of topical agents like moisturiser and NSAIDs.
- ✓ Maintain consistent hydration and controlled release of bioactive compounds curcumin and levomenthol.



Disadvantages of Wet Wrap Therapy:

- Works by using a damp gauze (which dries quickly) followed by a dry layer to retain moisture temporarily.
- Bandages must be changed every 1-2 hours.
- The warm, damp environment caused by wet wrap makes the user prone to infections (commonly *Staphylococcus aureus* infections).
- Can cause further breakdown of the skin barrier once bandages are removed and the skin dries again.
- Often requires higher doses of NSAIDs or corticosteroids due to potential loss through touch or wrap changes.

Figure 1 FT-IR graph showing % transmission over wavelength for different hydrogel patches

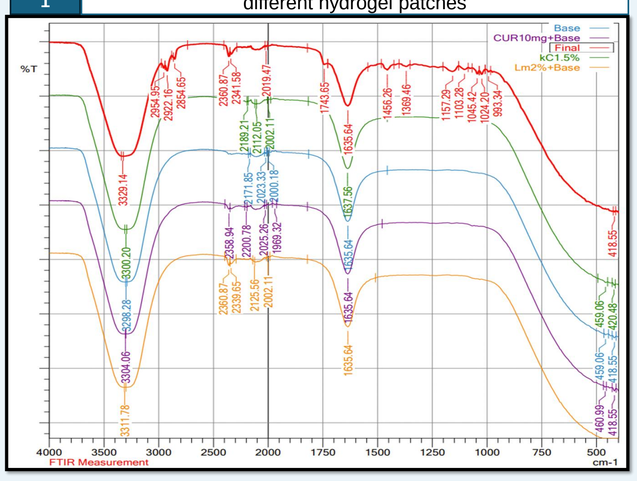


Figure 2 Drug release studies of hydrogel patches using UV-Visible spectrometer, graph showing absorbance over time

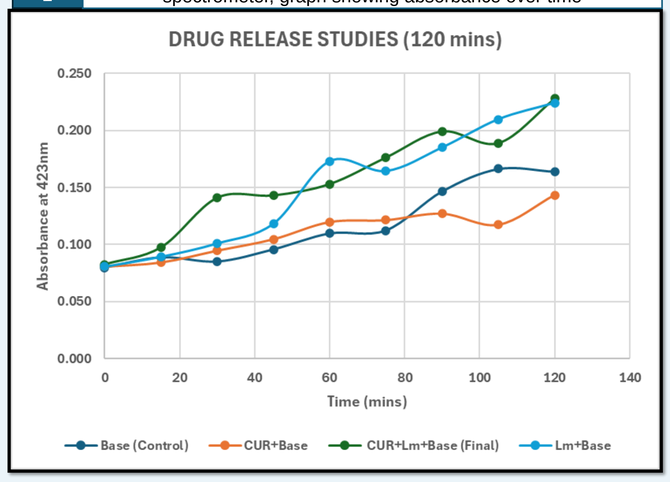


Figure 3 Cross section of Final hydrogel at 500µm magnification under SEM, showing microstructure and pore size

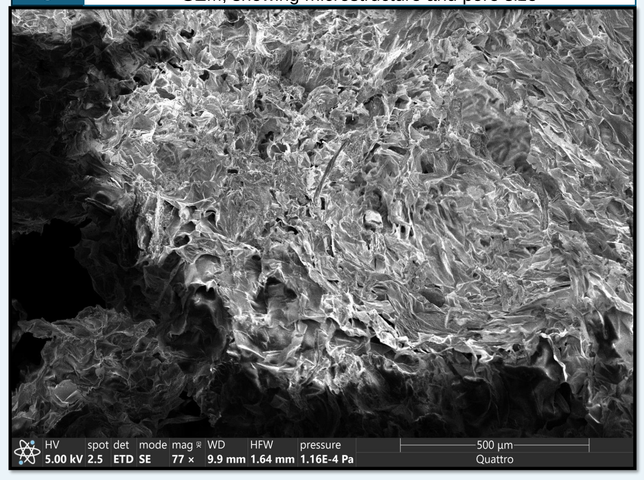


Figure 4 Well-diffusion antimicrobial studies of final and base (control) hydrogels

Results and Discussion

Final Hydrogel molecular stability and potential:

The **FT-IR spectra** of the final hydrogel show enhanced absorption in the C=O (~1745 cm^{-1}) and O-H (~3329 cm^{-1}), **indicating stronger carbonyl and ether linkages**. This is likely due to crosslinking or interaction with added curcumin, which influences the hydrogel's swelling behaviour, drug release profile, biocompatibility, and mechanical strength **(*Fig. 1*).**

Active ingredient loading and release capacity:

SEM imaging (*Fig. 3*) validated the porous structure of hydrogel. The large pore size indicates a greater holding capacity of water and active ingredients. A porous network also ensures adequate oxygen exchange, critical for wound healing and maintaining skin integrity.

Swelling studies proved hydrogel's high absorption and retention ability in acidic and neutral pH solutions, by swelling up to 150% in 45 minutes. **Drug release profiles (*Fig. 2*)** show slow, sustained release which is beneficial for prolonged therapeutic effects in treating AD.

Antimicrobial and anti-itch properties:

The preliminary studies using the final composition (containing curcumin) showed promising results in inhibiting the growth of *Staphylococcus aureus,* compared to the base (control) hydrogel **(*Fig. 4*).**

Future tests would involve in vitro tests on cell lines and eventually, in vivo testing of hydrogel patches on animal models to study wound healing and infection control.

Conclusion

Hydrogel patches composed of natural polymers; loaded with **anti-inflammatory, anti-microbial and anti-pruritic agents** such as curcumin and levomenthol represent a superior alternative to wet wrap therapy. Stronger molecular interaction of active ingredients within hydrogel displayed greater stability. Their ability to maintain consistent moisture, control drug release, and provide additional therapeutic benefits, makes them a more efficient, convenient, and safer option for the long-term management of severe AD.

References

The central animated images were created using Adobe Express image generator.

Langan, S.M., Irvine, A.D. and Weidinger, S. (2020). Atopic dermatitis. *The Lancet*, 396 (10247), 345–360.

Sandilands, A., Sutherland, C., Irvine, A.D. and McLean, W.H.I. (2009). Filaggrin in the frontline: role in skin barrier function and disease. *Journal of Cell Science*, 122(9), 1285–1294.

Margolis, D.J., Paller, A.S., Schwarzenberger, K., Simpson, E.L., Williams, H.C., Elmets, C.A. and Block, J. (2014). Guidelines of care for the management of atopic dermatitis. *Journal of the American Academy of Dermatology*, 71(6), 1218–1233.

Tian, J., Zhang, D., Yi Ching Yang, Huang, Y., Wang, L., Xu, Y. and Lu, Q. (2023). Global epidemiology of atopic dermatitis: a comprehensive systematic analysis and modelling study. *British Journal of Dermatology*, 190(1), 55–61.

Acknowledgements

Special thanks to:
UURIP team and NIHR for funding, Chawalpat Siripanich, Yan-Ching Chow, Asif Mowla, Amrutha Sunny, Sergey Zlatogorsky, Sarah Dennison, and the Analytical Suite technicians.