

Extended Abstract

ChromPATCH: Cutting-Edge *Chromolaena odorata*-Loaded Hybrid Hydrogel Wound Dressing Material for Sustained Healing

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ABSTRACT

Wound management remains a global challenge, particularly for delayed healing and severe infections. Hydrogel dressings have emerged as advanced wound care materials, with increasing interest in incorporating bioactive compounds such as plant extracts. *Chromolaena odorata* (*daun kapal terbang*), often considered an invasive species, possesses antioxidant, antibacterial, anti-inflammatory, and wound-healing properties. This study harnessed its medicinal potential to develop a novel, eco-friendly biopolymer hydrogel wound dressing. The hydrogel, formulated using cross-linked chitosan and polyvinyl alcohol (PVA), demonstrated excellent mechanical strength, high swelling capacity, and antibacterial activity—key characteristics of an ideal wound dressing. The strong swelling behaviour of PVA and chitosan ensures extended wound contact and gradual release of *C. odorata* extract, enabling controlled, sustained bioactive delivery. The hydrogel's release profile follows zero-order kinetics with a diffusion-dominated mechanism, as described by the Higuchi and Korsmeyer-Peppas models, ensuring a moist wound environment and prolonged therapeutic effect. This biocompatible and mechanically resilient hydrogel represents a sustainable, plant-based innovation in wound care, offering an effective alternative for enhanced healing.

Keywords: *Chromolaena odorata*, PVA/chitosan, sustained release, wound healing.

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1.0 Introduction

Wound healing is a complex biological process that remains a significant global healthcare challenge, particularly for chronic or non-healing wounds, which pose substantial risks of infection and morbidity. The selection of appropriate wound dressings is critical to facilitate the healing process, minimise complications, and improve patient outcomes. Traditional dressings often fall short of providing optimal moisture balance, antimicrobial properties, and the necessary support for tissue regeneration. Recent innovations in wound management have led to the emergence of hydrogel dressings, which offer numerous advantages, including moisture retention, gas exchange, and protection against external contaminants.

Combining polyvinyl alcohol (PVA) and chitosan in a hybrid hydrogel offers several advantages over using each polymer alone. While PVA provides excellent mechanical strength and stability, it lacks essential antibacterial properties (1). On the other hand, chitosan enhances antibacterial activity but may not provide the same level of mechanical robustness as PVA (2). By combining these two polymers, the resulting hydrogel benefits from the strengths of both materials, resulting in improved mechanical properties, antibacterial activity, and optimal moisture retention, which are crucial for effective wound healing.

C. odorata, locally known as *daun kapal terbang*, is a perennial shrub often considered an invasive species due to its aggressive growth and ability to outcompete native flora. Despite its negative reputation, this plant has demonstrated significant medicinal potential, with reported antioxidant, antibacterial, anti-inflammatory, hemostatic, and wound-healing properties (3). Prior studies have highlighted the effectiveness of *C. odorata* in enhancing wound healing, making it a promising candidate for incorporation into

wound dressings (4). The transformation of this problematic plant into a valuable resource aligns with sustainable resource management practices and offers pharmacological benefits, showcasing a unique opportunity to harness nature's potential for healing.

Motivated by the dual opportunity of utilising an invasive plant and enhancing wound healing, a novel biopolymer hydrogel wound dressing infused with *C. odorata* extract, ChromPATCH, was developed (5). This hydrogel, cross-linked with chitosan and PVA, demonstrates excellent mechanical strength, high swelling capacity, and significant antibacterial activity key characteristics of an ideal wound dressing.

2.0 Innovation

The uniqueness of ChromPATCH lies in its innovative use of *C. odorata*, a commonly problematic invasive plant species by transforming it into a valuable resource for wound care. This approach not only addresses environmental concerns by managing invasive plant species but also harnesses their medicinal potential for therapeutic use. Integrating PVA, chitosan, and *C. odorata* extract into a single hydrogel matrix offers a multi-functional wound dressing with enhanced mechanical properties, swelling behaviour, good hydrophilicity, adequate antimicrobial activity, and sustained bioactive release.

To support the formulation's efficacy, various tests were conducted, including cytotoxicity assessments that revealed the hydrogel were non-toxic towards Human keratinocytes (HaCaT) cells over seven days, indicating its biocompatibility (Figure 1(a)). The wound scratch assay also demonstrates that the hydrogel significantly enhances cell proliferation within 24 hours, achieving 100% wound closure *in vitro* (Figure 1(b)). These findings affirm the hydrogel's suitability as an advanced wound dressing,

providing a comprehensive solution that effectively addresses multiple wound care challenges.

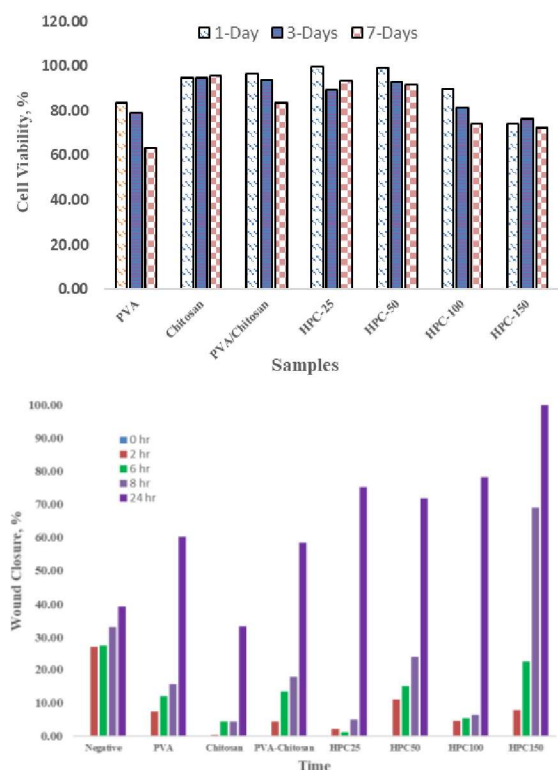


Figure 1: *In vitro* potency of ChromPATCH. (a) HACAT cell viability for Day 1, Day 2 and Day 7; (b) Wound closure rate (%) over time (0, 2, 6, 8, and 24 hours) based on the scratch assay of HACAT cells.

Furthermore, compared to traditional wound dressings, ChromPATCH provides a controlled and sustained release of therapeutic agents to support faster wound healing. This allows the hydrogel to release active agents gradually, maintaining prolonged therapeutic effects while preventing bacterial colonisation. The release profile of the hydrogel aligns with zero-order. The Higuchi and Korsmeyer-Peppas model suggest a diffusion-dominated mechanism that facilitates consistent bioactive delivery over time (Figure 2).

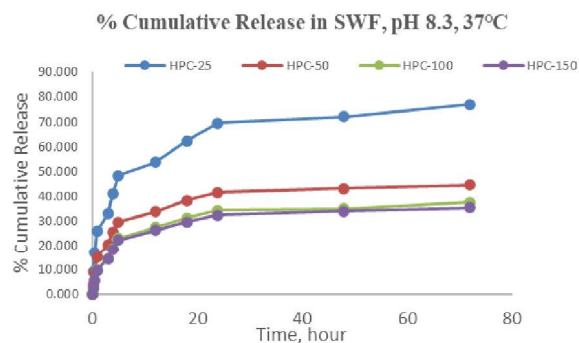


Figure 2: *In Vitro* Cumulative release of *C. odorata* extract in SWF, pH 8.3, 37°C.

3.0 Uniqueness

The combination of PVA and chitosan forms a highly absorbent, mechanically stable hydrogel with desirable mechanical and swelling properties. These characteristics ensure prolonged contact with the wound, enabling sustained release of *C. odorata* extracts. PVA provides the necessary structural integrity, while chitosan contributes bioactive properties that reduce microbial contamination and inflammation. Incorporating *C. odorata* leverages its bioactivity, providing an eco-friendly and functional enhancement to the hydrogel, aligning with Quality-by-Design (QbD) principles.

ChromPATCH distinguishes itself through its innovative formulation strategy, transforming an invasive plant into a valuable healthcare resource. This unique combination positions ChromPATCH as a cutting-edge solution in wound management, with significant implications for environmental sustainability and patient care.

4.0 Commercialisation Potential

The commercialisation of ChromPATCH will significantly be supported by its adherence to regulatory standards and the adoption of the Quality by Design (QbD) approach during the formulation stages. Comprehensive testing protocols were conducted to validate ChromPATCH's performance (Table 1). Mechanical testing was performed

according to American Society for Testing and Materials protocols to assess the hydrogel's tensile strength and elasticity. Cytotoxicity was evaluated using the MTT assay per ISO 10993 to confirm that ChromPATCH is non-toxic to HaCaT cells over 7 days. Antimicrobial activity was assessed against *Streptococcus aureus* following Clinical and Laboratory Standards Institute guidelines demonstrating effective infection management.

In addition, the economic potential of ChromPATCH could be regarded as substantial as it addresses the increasing demand for advanced wound care solutions, particularly in aging populations and patients with chronic wounds. By transforming the problematic *C. odorata* plant into a valuable resource, ChromPATCH offers a sustainable and eco-friendly solution and minimises raw material costs, hence positioning ChromPATCH as a cost-effective solution in the healthcare market. Future efforts will focus on clinical trials to further substantiate its efficacy, expand market access, and foster partnerships with healthcare providers, industries, and distributors.

Table 1: Key Performance Attributes of ChromPATCH

| Attributes | Description |
|------------------------|---|
| Mechanical Strength | Adequate tensile strength and flexibility. |
| Swelling Capacity | Maintains moisture, ensuring prolonged wound contact, proven hydrophilicity. |
| Antibacterial Activity | Effective against <i>Streptococcus aureus</i> |
| Cytotoxicity | Non-toxic to HaCaT cells over 7 days |
| Healing Efficacy | Achieves 100% wound closure within 24 hours |
| Release Profile | It follows zero-order and Higuchi kinetics, a diffusion-dominated mechanism described by the Korsmeyers-Peppas model. |

5.0 Impact on Quintuple Helix

The development of ChromPATCH offers broad-reaching impacts across the Quintuple

Helix. From an environmental perspective, it transforms an invasive plant species into a valuable resource, supporting sustainability goals. For society, it offers a cost-effective wound care solution that addresses global healthcare needs, particularly in regions with high rates of chronic or infected wounds. In the academic realm, it advances research into biopolymer hydrogels and plant-based medicine, encouraging further exploration into sustainable wound care technologies. From an industry standpoint, ChromPATCH offers a scalable, innovative product that can capture significant market share, while government support for environmentally conscious solutions enhances its potential for policy-driven growth.

6.0 Conclusion

ChromPATCH is an eco-friendly, biocompatible hydrogel that integrates PVA, chitosan, and *C. odorata* extract for enhanced wound healing. It enables sustained drug release, achieves 100% wound closure in 24 hours, and exhibits antibacterial activity. By repurposing an invasive plant, ChromPATCH offers a sustainable, effective, and safe wound care solution.

Authorship contribution statement

NAM: Data analysis, Methodology, Formal analysis, Writing—original draft. **FMT:** Writing – review & editing. **NBAK:** Supervision Resources, Funding acquisition, Draft corrections. **WNHI:** Writing – review & editing. **SNF:** Writing – review & editing. **EY** – Collaboration, review & editing.

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Conflict of Interest

The authors declared that they have no conflicts of interest to disclose.

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