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FORMULATION & EVALUATION OF INDOMETHACIN-LOADED HYDROGEL BANDAGES FOR WOUND HEALING

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ABSTRACT

The present study focuses on the formulation and evaluation of an indomethacin-loaded hydrogel film for transdermal drug delivery. Indomethacin, a non-steroidal anti-inflammatory drug, was incorporated into a polymeric matrix composed of polyvinyl alcohol (PVA) and hydroxypropyl methylcellulose (HPMC) using the solvent casting method. PEG 400 was used as a solvent for drug incorporation, while glycerin acted as a plasticizer and propyl paraben as a preservative. The prepared hydrogel film was evaluated for various physicochemical parameters including physical appearance, thickness, weight variation, surface pH, drug content uniformity, and in-vitro drug release. The film was found to be transparent, smooth, and uniform in appearance, with an average thickness of 1.5 mm and consistent weight distribution. The surface pH (6.82) indicated good compatibility with skin, minimizing the risk of irritation. Drug content analysis showed uniform distribution of indomethacin within the film, with a linear calibration curve confirming analytical accuracy. In-vitro dissolution studies revealed a sustained and controlled drug release profile over 60 minutes, demonstrating effective drug diffusion from the polymer matrix. Overall, the formulated hydrogel film exhibited desirable characteristics for transdermal application and can be considered a promising alternative for controlled delivery of indomethacin.

KEYWORDS: Indomethacin, Hydrogel film, Transdermal delivery, PVA, Drug release.

INTRODUCTION

Wound healing is a coordinated, multi-phase biological process that restores the integrity of damaged tissue after injury, primarily involving the skin.[1] It is commonly divided into four overlapping phases hemostasis (clot formation and

vasoconstriction), inflammation (leukocyte recruitment, debris clearance, and cytokine release), proliferation (fibroblast-driven collagen deposition, angiogenesis, and re-epithelialization), and maturation/remodeling (collagen reorganization and scar maturation over weeks to months).[2] Efficient healing depends on vascular supply, microbial control, and an appropriate balance of inflammatory and reparative signals; disruption of these phases leads to delayed healing, chronic ulcers, or excessive scarring, making modulation of this cascade a key target for novel drug-delivery systems.[3,4]

Classification of Wounds

Wounds can be classified in several ways relevant to management and evaluation. By tissue discontinuity, they are divided into open (abraded, lacerated, incised, punctured, avulsed, surgical) and closed (bruises, hematomas).[5]

By depth, they are categorized as superficial, partial-thickness, full-thickness, or deep-and-complicated, reflecting involvement of epidermis, dermis, subcutaneous tissue, and underlying organs or cavities. Wounds are also distinguished by age (acute vs chronic), cause (traumatic, surgical, pressure sores, diabetic foot ulcers, venous stasis ulcers), and surgical contamination class (clean, clean-contaminated, contaminated, dirty/infected), which directly influence infection risk, healing potential, and suitability for different dressing types and drug-delivery platforms.[6]

Role of Hydrogels in Wound Management

Hydrogels play a central role in wound management by providing a moist, conformable, and protective interface at the wound bed while supporting drug delivery and tissue repair.[7] Composed of three-dimensional, water-rich polymer networks, they absorb exudate, maintain hydration, and enhance autolytic debridement without maceration, thereby accelerating re-epithelialization and reducing pain. When loaded with anti-microbial, anti-inflammatory, or growth-factor-like agents, hydrogels act as localized, sustained-release systems that improve infection control, angiogenesis, and granulation-tissue formation, particularly in chronic and burn-wound models. This dual role as both wound-dressing and drug-delivery vehicle makes hydrogels highly attractive for advanced formulations such as indomethacin- or herbal-loaded bandages.[8]

Advantages of Hydrogel Bandages

Hydrogel bandages offer several advantages over conventional gauze or simple adhesive dressings. They maintain a moist wound environment that promotes keratinocyte migration and epithelialization, while absorbing excess exudate and preventing tissue desiccation. The hydrated, gel-like structure provides cooling and pain relief, especially in burns and inflamed wounds, and the soft, conformable matrix adapts to irregular wound contours and body surfaces.[9]

Hydrogel bandages cause minimal trauma on removal, reduce the need for frequent dressing changes, and can be engineered to deliver antimicrobial, anti-inflammatory, or herbal actives in a sustained manner, improving local therapeutic effect with lower systemic exposure. These properties make them particularly suitable for chronic, painful, or exudate-prone wounds, including those associated with diabetes and neuropathic pain.[6,10]

Pharmacological Profile of Indomethacin

Indomethacin is a potent non-steroidal anti-inflammatory drug (NSAID) of the indole acetic-acid class, acting primarily as a non-selective cyclooxygenase (COX-1 and COX-2) inhibitor that blocks the production of prostaglandins and thromboxanes. This mechanism underlies its strong anti-inflammatory, analgesic, and antipyretic effects, making it

effective in rheumatoid arthritis, ankylosing spondylitis, acute gout, and certain headache disorders.[11] Systemically, indomethacin is rapidly absorbed, highly protein-bound, and largely eliminated via hepatic metabolism and renal excretion, with a short plasma half-life that often necessitates divided-dose regimens. However, its use is limited by dose-related gastrointestinal ulceration and bleeding, renal impairment, and cardiovascular risk, which has fostered interest in localized delivery strategies such as transdermal or hydrogel-based formulations.[12]

Rationale for Indomethacin-Loaded Hydrogel Bandages

The rationale for developing indomethacin-loaded hydrogel bandages is to harness the potent anti-inflammatory and analgesic action of the drug directly at the wound or affected site while minimizing systemic toxicity and gastrointestinal complications.[13] Conventional oral administration of indomethacin carries a high risk of ulcerogenic and cardiovascular side effects, whereas topical hydrogel systems can deliver the drug slowly and locally into the dermis and subcutaneous tissue, suppressing prostaglandin-mediated inflammation and pain with reduced systemic exposure.[6,14] Hydrogel bandages additionally provide a moist, protective, and conformable wound interface that supports healing while absorbing exudate and relieving pain, making them especially suitable for inflamed surgical, traumatic, or chronic wounds.[11] Loading indomethacin into a hydrogel matrix therefore combines the pharmacological potency of an established NSAID with the beneficial physical and biological properties of advanced wound-dressing materials, offering a promising approach for managing inflammatory and painful dermatological conditions.[9,15]

METHODOLOGY

Table No. 1: List of ingredients with quantity.

S. No.	Ingredients	Quantity(100g)
1	Indomethacin	0.5g
2	Polyvinyl alcohol	5g
3	HPMC	3g
4	PEG400	10g
5	Glycerin	5g
6	Propyl paraben	0.03g
7	Distilled water	q.s to 100g

The hydrogel film was prepared using the solvent casting method. Initially, 5 g of polyvinyl alcohol (PVA) was dissolved in 50 mL of distilled water by heating at 80–90°C with continuous stirring until a clear viscous solution was obtained. The solution was then cooled to room temperature, followed by the gradual addition of 3 g of hydroxypropyl methylcellulose (HPMC) with continuous stirring. The polymeric mixture was allowed to stand undisturbed for 40 minutes to 1 hour to ensure complete hydration and swelling of polymers. Separately, 0.5 g of indomethacin was dissolved in 10 g of PEG 400 at 40–50°C to obtain a uniform drug solution. In another beaker, 0.03 g of propyl paraben was dissolved in 10 mL of warm distilled water (60°C). The drug solution was then incorporated into the polymeric mixture under continuous stirring for 10–15 minutes at room temperature. Subsequently, the preservative solution was added slowly and mixed thoroughly. Further, 5 g of glycerin was added as a plasticizer and stirred for 10 minutes to obtain a homogeneous gel. The prepared gel was allowed to stand for 24 hours to remove entrapped air bubbles. The gel was then poured onto a petri dish and spread uniformly using a glass rod to maintain consistent thickness. The film was dried at room temperature for 24–48 hours. After drying, the film was carefully peeled, cut into uniform pieces, and mounted onto bandages.

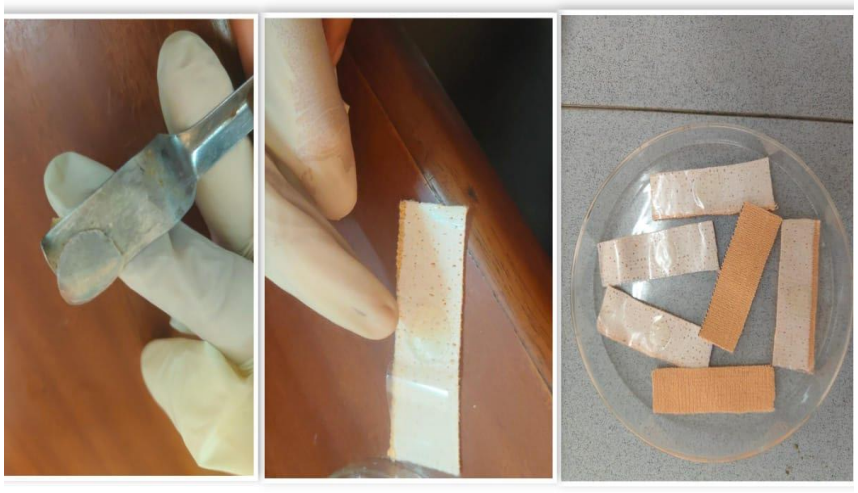

Figure 1: Indomethacin-loaded hydrogel bandages for wound healing.

RESULT

1. Physical Appearance

The prepared hydrogel film was visually inspected against a light background and was found to be transparent, smooth, and uniform, indicating proper film formation.

2. Thickness

Film thickness was measured at three different points using a vernier caliper.

Table No. 2: Thickness of 3 samples measured by vernier caliper.

Sample	Main Scale Reading (cm)	Vernier Reading (n)	n × Least Count (cm)
t1	0.1	5	0.05
t2	0.2	5	0.05
t3	0.1	6	0.06

Average Thickness: 0.15 cm (1.5 mm)

This indicates uniform thickness, which is ideal for transdermal films.

3. Average Weight

Equal-sized film samples were weighed to determine uniformity.

Table No. 3: Average weight of 3 samples.

Sample	Film Weight (g)	Bandage Weight (g)
W1	0.07	1.19
W2	0.08	1.18
W3	0.07	1.19

Average film weight: 0.073 g

Average bandage weight: 1.187 g

The results indicate good uniformity in film weight

This shows ideal weight of any uniform film.

4. Surface pH

The film was soaked in distilled water for 30 minutes, and pH was measured using a digital pH meter. Surface pH: 6.82 This pH is close to skin pH, indicating good compatibility and low irritation potential.

5. Drug content uniformity

The drug content was analyzed using a UV–Visible spectrophotometer at 320 nm. A calibration curve was prepared using phosphate buffer (pH 7.4).

The calibration curve showed good linearity with a correlation coefficient close to 1, i.e After applying linear regression analysis, R^2 value ≈ 0.9987 confirming uniform drug distribution.

6. In-vitro Drug Release Study

The dissolution study was performed using USP dissolution apparatus I (basket method). The study conditions were 900 mL phosphate buffer (pH 7.4), temperature: 37 ± 0.5°C, speed: 50–100 rpm, samples were withdrawn at specified intervals and analyzed spectrophotometrically.

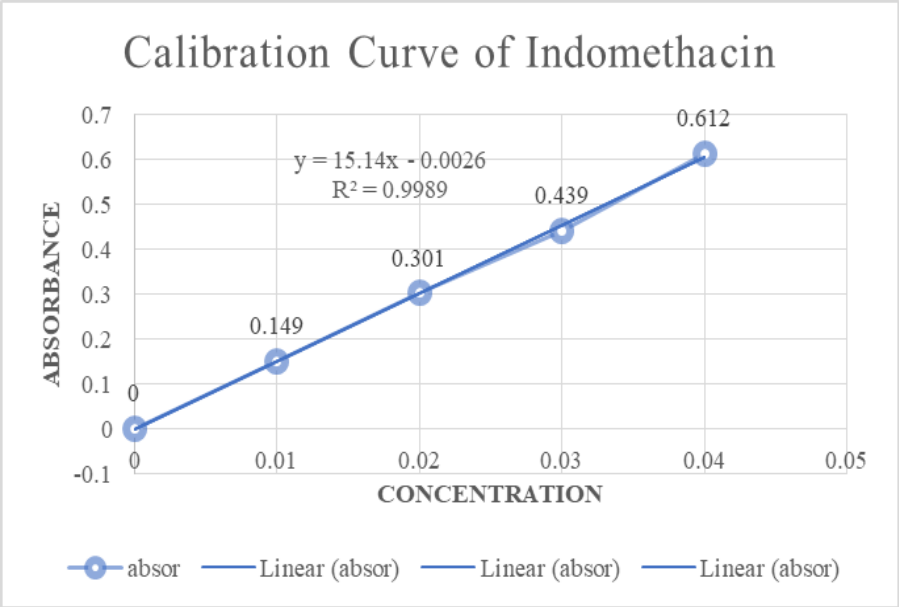

Figure No. 2: Calibration curve of indomethacin.

Table No. 4: Drug content uniformity.

Time(mins)	Absorbance	Concentration (mg\ml)
0	0	0
5	0.149	0.01
10	0.301	0.02
15	0.439	0.03
30	0.612	0.04
60	0.821	0.05

The results demonstrate a gradual and sustained drug release profile, indicating good bioavailability of the formulated hydrogel film, indicating maximum bioavailability.

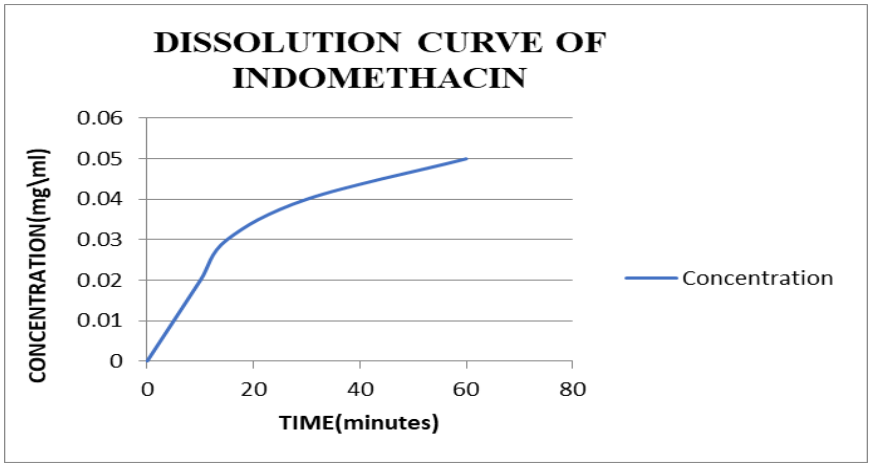

Figure No. 3: Dissolution curve of indomethacin.

CONCLUSION

The present study successfully developed an indomethacin-loaded hydrogel film using a combination of PVA and HPMC polymers through the solvent casting technique. The formulated film demonstrated satisfactory physicochemical properties, including uniform thickness, consistent weight, smooth texture, and transparency, indicating proper formulation and film formation. The surface pH of the film was found to be within the acceptable range for topical application, suggesting good skin compatibility. Drug content uniformity confirmed homogeneous distribution of the drug throughout the polymeric matrix. The in-vitro drug release study exhibited a sustained release pattern, which is advantageous for prolonged therapeutic action and improved patient compliance. Based on the obtained results, the developed hydrogel film shows significant potential as a transdermal drug delivery system for indomethacin. Further studies such as stability testing, skin permeation studies, and in-vivo evaluation are recommended to establish its clinical efficacy and safety.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research work.

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