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Sphatika Hydrogel: A Convergence of Ayurvedic Wisdom and Contemporary Drug Delivery Systems

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ABSTRACT

The rising interest in natural and traditional remedies has driven renewed exploration into Ayurvedic formulations, particularly for therapeutic applications such as wound care. Among the many classical ingredients, Sphatika (Potash alum) holds a prominent place in Ayurvedic literature due to its well-documented astringent, antimicrobial, and wound-healing properties.

The present study aims at the pharmaceutical preparation of a Sphatika-based hydrogel by integrating the classical wound-healing principles of Ayurveda with the targeted and sustained delivery capabilities of modern pharmaceutical technology.

The hydrogel was prepared using biocompatible polymers such as Gaur gum and Glycerin, chosen for their soothing, hydrating, and stabilizing properties. The formulation process focused on achieving optimal consistency and spreadability suitable for topical application.

This work highlights the potential of combining Ayurvedic principles with contemporary formulation science to create innovative, effective, and natural therapeutic alternatives. Such integrative approaches could pave the way for sustainable and culturally resonant pharmaceutical products.

KEYWORDS: Sphatika, Potash Alum, Hydrogel, Transdermal Application, Wound healing

INTRODUCTION

Wound management has been a well-established domain within Ayurvedic medicine since ancient times, encompassing a comprehensive understanding of the stages of wound healing, the classification of wounds, and the therapeutic interventions required for effective recovery. The classical Ayurvedic texts—including Sushruta Samhita and Charaka Samhita—detail a wide array of treatment protocols under the concept of Vrana Ropana (wound healing), emphasizing not only the physical healing of tissue but also the restoration of function and prevention of complications. These treatments are grounded in the use of herbal, mineral, and metallic preparations possessing Shodhana (cleansing/purification), Ropana (healing), Stambhana (hemostatic/arresting bleeding), and Krimighna (antimicrobial/anti-parasitic) properties.

Ayurveda adopts a holistic approach to wound care, considering factors such as Dosha imbalance (Vata, Pitta, and Kapha), tissue involvement, and the overall vitality (Ojas — essence of immunity and strength) of the individual. Various topical applications, decoctions, Lepas (herbal pastes), and medicated oils or ghee preparations have been traditionally employed to cleanse wounds, reduce inflammation, facilitate granulation, and promote tissue regeneration. This time-tested approach continues to inspire contemporary interest in formulating natural and integrative therapies for skin and soft tissue repair.

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Sphatika (Potash alum, $KAl_2(SO_4)_2,12H_2O$) —, a mineral compound extensively referenced in traditional formulations for its haemostatic and antiseptic actions(Gajbhiye, 2025)

Rasa (Taste)	Kashaya (Astringent), Katu (Pungent), Tikta (Bitter)
Guna (Qualities)	Snigdha (Unctuous), Guru (Heavy)
Veerya (Potency)	Ushna (Hot)
Karma (Actions)	Vishadoshahara (Alleviates poison/toxin disorders), Visarpahara (Relieves spreading skin diseases), Kandughna (Anti-itch), Keshya (Promotes hair health), Shwithrapaha (Alleviates leucoderma), Vrana Ropana (Wound healing), Netra Roga Prashamana (Relieves eye diseases), Vishama Jwara Nashini (Relieves irregular fever), Vranaharini (Removes wounds), Sankochaka (Astringent/constricts tissues), Grahi (Absorbent/reduces discharge), Lekhani (Scraping property), Rudhirasravarodhini (Stops bleeding), Mukha Rogahara (Relieves oral diseases), Danta Dardyakari (Strengthens teeth), Sthambana (Styptic/hemostatic)

Table 1. Properties of Sphatika(Sarma, 2015)

Simultaneously, advancements in drug delivery systems have positioned hydrogels as highly favourable vehicles for topical wound applications. Hydrogels are three-dimensional, hydrophilic polymer networks capable of retaining substantial quantities of water while maintaining structural integrity(M et al., 2021). Their intrinsic characteristics—such as providing a moist wound environment, promoting autolytic debridement, and facilitating localized, sustained drug release—make them ideal platforms for incorporating therapeutic agents aimed at enhancing wound repair and preventing infection(Chandira, 2022)

This novel preparation seeks to enhance the bioactivity and application efficiency of Sphatika through a modern hydrogel matrix, offering improved physicochemical properties, patient acceptability, and therapeutic outcomes.

MATERIALS AND METHODS

Ingredients

Sphatika (Potash alum, pharmaceutical grade, crystalline form) [Certified Ayurvedic raw drug supplier],

Guar gum (pharmaceutical grade; Cyamopsis tetragonoloba) [BRM Chemicals, Old Delhi, India],

Glycerin (pharmaceutical grade) [SD Scientifics, Mangalore, India],

Borax (Sodium tetraborate; analytical grade) [SD Scientifics, Mangalore, India],

Distilled water (purified) [Laboratory source] were used in the formulation.

Method of Preparation

Safety Precautions:

All procedures were conducted under aseptic conditions in a clean laboratory environment. All glassware and equipment were sterilized prior to use.

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Shodhana of Sphatika(Sudarshan et al., 2025)

Open method of heating**:** Ashuddha Sphatika weighing 100g was taken in an iron pan and subjected to heat. It started melting at the temperature of 110°C. The heat was continued till all the water from Sphatika evaporated and it turned anhydrous. At the end of the process, a dull white coloured Sphatika was formed. Later it was taken out from the fire and kept for cooling. After sometime, the Shuddha Sphatika was collected by scraping the iron pan which weighed 72g.

Hydrogel Preparation

Step 1: Preparation of Sphatika Solution

5 g of Sphatika was accurately weighed and dissolved in 40 g of Distilled water in a clean beaker. The solution was stirred continuously using a magnetic stirrer with hot plate (Rotations-500rpm, Temperature-40^{o}C) until complete dissolution was achieved, forming the aqueous phase containing the active compound.

Step 2: Dispersal of Guar Gum and Addition of Glycerin

In a separate sterile beaker, 2 g of Guar gum was weighed. To this, 2 g of Glycerin was slowly added while stirring continuously. Glycerin acted as a wetting and dispersing agent, helping to evenly hydrate the Guar gum and prevent the formation of lumps. Stirring was continued until a smooth, lump-free dispersion was obtained.

Step 3: Incorporation of Sphatika Solution into Polymer Base

The previously prepared Sphatika solution was gradually added to the Guar gum–Glycerin dispersion with constant stirring. The mixture was stirred thoroughly for 20–30 minutes to ensure homogeneity and uniform distribution of the active compound. The hydrated dispersion was then allowed to rest for 30–60 minutes at room temperature (25±2^{o}C) to ensure full swelling of the Guar gum and stabilization of the matrix.

Step 4: Preparation of Borax Solution (4% w/w)

A 4% w/w Borax solution was prepared by dissolving 0.4 g of Borax in 9.6 g of Distilled water, yielding a 10 g stock solution. The solution was stirred until clear and then kept aside for the cross-linking step.

Step 5: Gelation and Cross-linking

The prepared 4% Borax solution was added dropwise to the Guar gum–Sphatika–Glycerin mixture under continuous stirring. Cross-linking between borate ions and the hydroxyl groups in Guar gum triggered gel formation. Typically, 5–7 g of the Borax solution was sufficient to obtain a hydrogel with optimal viscosity and consistency. The addition was halted upon achieving a stable gel matrix.

Step 6: Final Homogenization and Storage

The final hydrogel formulation was gently stirred to ensure uniformity and then transferred into a sterile, airtight glass container. The container was appropriately labelled and stored in a cool, dry place at ambient temperature (25 ± 2°C), protected from light and microbial contamination.

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Figure 1. Ashuddha Sphatika-Measured -100g

Figure 2. Pounded into small pieces

Figure 3. Open heating of Ashuddha Sphatika

Figure 4. Evaporation of water molecules

Figure 5. After complete evaporation of water molecules, Sphatika becomes anhydrous-Shuddha Sphatika

Figure 6. Pounded to make it into fine powder.

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Figure 7. Weighing of Shudha Sphatika- 5g

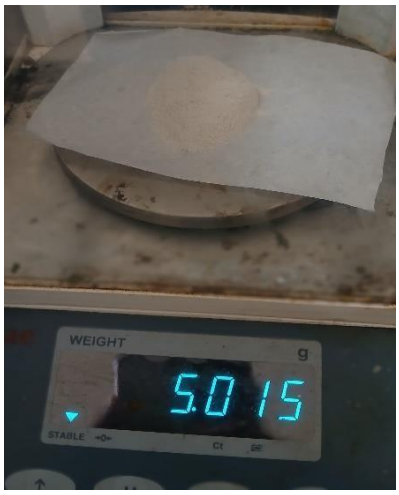

Figure 8. Weighing of Guar gum- 2g

Figure 9. Weighing of Borax- 4g

Figure 10. Addition of Glycerin(2g) to the beaker

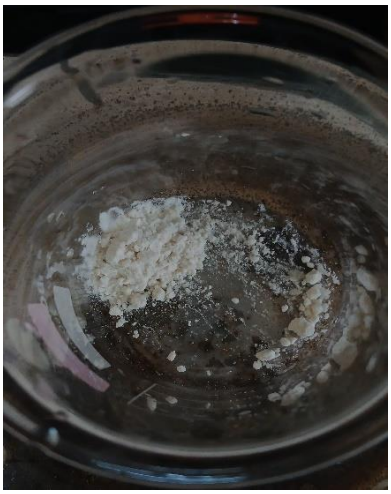

Figure 11. Addition of Guar gum to the Glycerin

Figure 12. Addition of Sphatika Solution to the Guar gum mixture

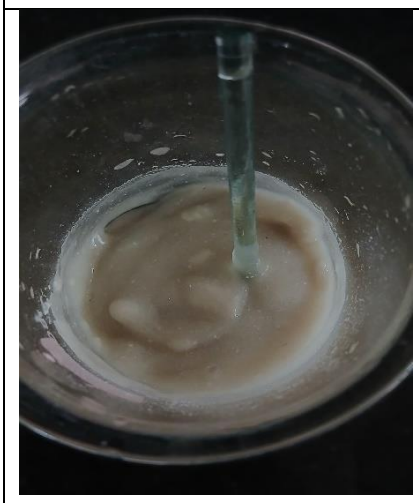

Figure 13. Mixing of the mixture after adding 4% Borax Solution

Figure 14. The mixture if let to sit for an hour

Figure 15. Final product- Translucent Sphatika Hydrogel- 55g

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OBSERVATIONS AND RESULTS

Observations During the Preparation

Preparation of Sphatika Solution

Sphatika (Potash alum) crystals dissolved in Distilled water.

The solution turned clear and colourless, with no residue remaining.

Mild heat (40^0C) facilitated dissolution and increased clarity.

Preparation of Gel Base

Gelling agent swelled upon hydration.

Required continuous stirring to avoid clumping.

Gel became translucent and viscous over time.

Proper hydration took approximately 20–30 minutes.

Mixing of Sphatika Solution with Gel Base

Sphatika solution blended easily into the gel base.

Stirring had to be gentle to avoid air entrapment.

Final hydrogel was homogeneous, semi-solid, and transparent.

No precipitation or phase separation observed after mixing.

Physical Characterization of the Prepared Hydrogel

Parameter	Observation
Appearance	Translucent gel
Colour	Greyish-white
Odour	Odourless
Texture	Smooth, non-gritty
Consistency	Semi-solid, uniform
Washability	Easily washable with water

Table 2. Physical Characterization of the Prepared Hydrogel

DETAILED DESCRIPTION AND COMPARATIVE ANALYSIS

The prepared Sphatika hydrogel exhibited a translucent gel appearance with a greyish-white colour, indicating uniform dispersion of the active ingredient without visible particulate matter or precipitation. This is comparable to the findings of Trinadha Rao et al. (2021), who reported that the absence of opacity and sedimentation reflects good homogeneity and physical stability of hydrogel systems(M. et al., 2021)

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Washability was reported as "easily washable with water," which is advantageous for wound care products, enabling convenient removal without mechanical irritation to the healing tissue. This property is consistent with carbopol-based hydrogels described by Yang et al. (2024), which maintained high moisture compatibility while being non-greasy and easy to rinse(Huang et al., n.d.)

RESULTS

Quantity Taken:

Ingredients	Quantity
Sphatika	5g
Guar gum	2g
Glycerin	2g
Distilled water	40g
Borax Solution	7g
Total Quantity	56g

Table 3. Sphatika Hydrogel Quantity

Quantity Obtained of product	55g
Yield Percentage	98.2%

Table 4. Quantity Obtained

pH- 5.2

The pH of the prepared formulation was found to be 5.2, indicating a mildly acidic character suitable for topical application.

DISCUSSION

Mechanism of Action – Ayurvedic Perspective

The therapeutic rationale behind the formulation of a Sphatika-based hydrogel lies in its ability to synergize the time-tested healing properties of Ayurvedic pharmacology with the targeted and sustained delivery mechanisms offered by modern pharmaceutical excipients. Sphatika is a mineral substance extensively mentioned in Ayurvedic texts for its efficacy in managing various types of Vrana (wounds), ulcers, and skin disorders. Its multifaceted therapeutic actions can be attributed to its unique combination of Rasa (taste), Guna (qualities), Veerya (potency), Vipaka (post-digestive effect), and Karma (therapeutic action).

Predominantly exhibiting Kashaya Rasa (astringent taste), Sphatika exerts a powerful Stambhana (hemostatic) and Sankochaka (constricting) action. This results in vasoconstriction at the wound site, aiding in immediate hemostasis, minimizing serous exudate, and facilitating wound edge contraction. This astringency also supports the restoration of barrier function by reducing local moisture imbalance and suppressing microbial proliferation. The Katu (pungent) and Tikta (bitter) Rasas further add to its Shodhana (cleansing) and Lekhana (scraping or debriding) actions, enabling the removal of necrotic debris and maintaining a clean wound bed

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conducive to healthy granulation.

The Ushna Veerya (hot potency) of Sphatika enhances peripheral circulation, promoting tissue oxygenation and nutrient delivery to the wound site. This thermogenic action is especially beneficial in wounds influenced by Kapha and Vata Doshas, which are often characterized by sluggish healing and cold, pale tissues. By stimulating local metabolic activity, Ushna Veerya (hot potency) helps in Ama Pachana (digestion or elimination of toxic metabolic by-products) and initiates early inflammatory responses required for tissue repair.

In terms of Guna (qualities), Sphatika is described as Guru (heavy) and Snigdha (unctuous). These attributes contribute to stabilizing the wound environment and pacifying aggravated Vata, which governs tissue degeneration and pain. While Guru Guna (heavy quality) provides structural support and cellular anchorage, Snigdha Guna (unctuous quality) counteracts excessive dryness and prevents cracking or desiccation of healing tissue, ensuring epithelial continuity.

Sphatika's Krimighna Karma (antimicrobial activity) is of particular significance in modern wound care, especially amidst rising concerns of antibiotic resistance. Its inherent antiseptic and antifungal actions inhibit colonization of common wound pathogens, reducing the likelihood of secondary infections. Alongside, its Ropana Karma (healing action) facilitates rapid epithelialization, collagen remodelling, and scar minimization.

Additional actions such as Grahi (absorbent), Sankochaka (contracting), Raktasravarodhini (anti-hemorrhagic), and Shothahara (anti-inflammatory) further validate Sphatika's multidimensional wound-healing profile. By absorbing excessive discharge, controlling inflammation, and ensuring clean wound margins, Sphatika optimizes the healing microenvironment.

Synergistic Role of Formulation Components

While Sphatika serves as the principal bioactive compound, the efficacy and functionality of the hydrogel are significantly enhanced by the judicious selection of supportive excipients — Guar gum, Glycerin, and Borax — each contributing uniquely to the formulation's performance.

Guar gum(Mudgil et al., 2014), a natural galactomannan polysaccharide, plays a pivotal role in establishing the hydrogel matrix. Its gelling capacity enables the formation of a semi-solid, cohesive system that adheres effectively to the wound surface. The polymeric structure retains moisture while allowing gas exchange, creating an ideal moist wound-healing environment, which is crucial for promoting angiogenesis, collagen deposition, and autolytic debridement. Additionally, its exudate-absorbing capacity helps regulate wound moisture levels, preventing maceration and encouraging granulation tissue formation. Guar gum also acts as a barrier, protecting the wound from external contaminants.

Glycerin(Chen et al., 2022), a trihydroxy alcohol, is incorporated into the formulation as a humectant and plasticizer. It attracts and retains water molecules from both the environment and underlying tissues, maintaining hydration at the wound interface. This property is especially important in chronic wounds where dryness can delay epithelialization. Furthermore, Glycerin contributes to the spreadability and pliability of the hydrogel, ensuring ease of application and comfort during use. Its mild antimicrobial effect further enhances the overall bioactivity of the formulation.

Borax(Wang et al., 2022) functions primarily as a cross-linking agent, facilitating the gelation of Guar gum by forming borate ester linkages with the vicinal hydroxyl groups of the polysaccharide. This chemical interaction stabilizes the three-dimensional network of the hydrogel, giving it the desired consistency and mechanical stability. Beyond its structural role, Borax possesses antiseptic properties, which augment the antimicrobial effect of Sphatika, thereby offering dual antimicrobial coverage. The controlled incorporation of Borax ensures an optimal balance between gel firmness and flexibility, enhancing both efficacy and patient compliance.

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Integrative Efficacy and Formulation Significance

The hydrogel formulation exemplifies a synergistic integration of traditional Ayurvedic pharmacology with modern drug delivery technologies. The combination of Sphatika's bioactive properties with a biopolymer-based hydrogel system ensures localized, sustained release (Sharma, 2025) of therapeutic agents, reduced dosing frequency, and enhanced therapeutic outcomes. The bio adhesive nature of the hydrogel supports prolonged residence time at the wound site, while its occlusive yet breathable structure facilitates accelerated healing.

Importantly, all excipients used—Guar gum, Glycerin, and Borax—are biocompatible, biodegradable, and pharmaceutically acceptable, aligning the formulation with current demands for safe, non-toxic, and patient-friendly dosage form. The incorporation of classical Ayurvedic ingredients into such vehicles allows for the scientific validation and modernization of traditional medicine, contributing to a growing body of evidence supporting integrative and holistic wound management practices.

The formulation exhibited a pH of 5.2, which falls within the physiological range of the skin (4.5–5.5), indicating its suitability for topical application while simultaneously aiding in preservation by providing a mildly acidic environment that discourages microbial proliferation.

In conclusion, the Sphatika-based hydrogel represents a promising natural therapeutic for wound care applications, offering anti-inflammatory, antimicrobial, and tissue-regenerative effects through a scientifically optimized delivery system. This approach provides a compelling model for the fusion of classical Ayurvedic principles with contemporary pharmaceutical innovation.

Benefits of Hydrogel-Based Formulation

The hydrogel delivery system offers distinct advantages that enhance both the efficacy and usability of the formulation:

Moist Environment**:** Hydrogels maintain optimal moisture levels at the wound interface, accelerating healing and reducing scab formation.

Non-Adherent Application: The formulation does not stick to the wound bed, enabling atraumatic removal and minimizing damage to newly formed tissue.

Exudate Absorption: Guar gum's hydrophilic properties enable the absorption of wound exudates, which prevents maceration and keeps the wound environment balanced.

Barrier Function: The hydrogel acts as a protective barrier against environmental contaminants and microbial intrusion.

Ease of Application: The smooth consistency, aided by Glycerin, ensures uniform spreadability and patient comfort.

Potential for Sustained Release: Though not explicitly tested in this formulation, hydrogels are known to prolong drug release at the site of application, supporting consistent therapeutic levels over time.

LIMITATIONS AND FUTURE SCOPE

Despite its promising potential, the formulation and study of Sphatika hydrogel present certain limitations:

Need for clinical validation**:** While the formulation is pharmacologically sound and draws from traditional knowledge, rigorous preclinical and clinical trials are essential to validate safety, efficacy, and dosage optimization in diverse wound types.

Potential for localized irritation**:** The astringent nature of Sphatika may cause transient irritation in individuals

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with sensitive skin or compromised dermal barriers.

Stability and shelf life: Long-term physicochemical stability, microbial resistance of the formulation, and packaging materials need to be systematically assessed. Future directions include incorporating this hydrogel into comparative clinical trials, exploring its use in diabetic or infected wounds, and developing complementary delivery systems (e.g., hydrogel films or bandage- integrated formats) for advanced wound care applications.

CONCLUSION

Sphatika (Potash Alum), a time-honoured mineral extensively documented in Ayurvedic texts, holds significant therapeutic value in wound management owing to its Kashaya Rasa (astringent taste), Ushna Veerya (hot potency), and Krimighna Karma (antimicrobial action), Shothahara Karma (anti-inflammatory action), and Ropana Karma (healing action). The present study successfully formulated a Sphatika-based hydrogel by incorporating Guar gum, Glycerin, and Borax, creating a biocompatible, moist-retentive, and antimicrobial wound dressing system.

The hydrogel demonstrated favourable physicochemical characteristics and leveraged the synergistic interaction of its constituents: Guar gum provided the gel matrix and absorptive capacity, Glycerin maintained hydration and spreadability, and Borax facilitated gelation while contributing antiseptic activity. Collectively, the formulation supports multiple phases of wound healing, from inflammation modulation to tissue regeneration and microbial control.

This integrative approach reflects the harmonization of classical Ayurvedic knowledge with modern pharmaceutical technologies, yielding a promising, natural, and patient-friendly alternative to conventional wound care. Future translational studies and clinical evaluations may further establish its role in mainstream therapeutic regimens, supporting a more holistic and sustainable model of healthcare innovation.

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