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FORMULATION AND EVALUATION OF ALOE VERA BASED NANOGEL FOR TOPICAL APPLICATION

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ABSTRACT

The present study focuses on the formulation and evaluation of an Aloe vera-based nanogel for enhanced topical delivery. Aloe vera is widely recognized for its anti-inflammatory, antimicrobial, and wound-healing properties. However, its conventional gel formulations often suffer from limited skin penetration and stability issues. To overcome these limitations, a nanogel was developed by incorporating Aloe vera extract into a nanoemulsion system using high-energy emulsification techniques, followed by gelation with Carbopol 940. The prepared nanogel was evaluated for its physicochemical properties, including pH, viscosity, spreadability, particle size, and zeta potential. In vitro drug release studies demonstrated a sustained release profile, while antimicrobial assays confirmed enhanced antibacterial activity compared to conventional formulations. The Aloe vera nanogel also exhibited good stability over a three-month period. These results suggest that the nanogel formulation improves the therapeutic potential of Aloe vera and may serve as an effective delivery system for skin care and dermatological applications.

INTRODUCTION

Aloe vera (Aloe barbadensis Miller) is a medicinal plant widely used in skincare for its antibacterial, antioxidant, and healing properties. However, its efficacy is limited by poor stability and skin penetration. Nanotechnology offers a promising approach to improve bioavailability through nanogels-hydrogel systems containing nanosized particles that provide controlled drug delivery and enhanced skin permeation.

Aloe vera is a well-known medicinal plant extensively used in traditional and modern medicine due to its remarkable therapeutic properties, including anti-inflammatory, antimicrobial, antioxidant, and wound-healing activities. The gel extracted from the inner part of the Aloe vera leaf contains bioactive compounds such as polysaccharides, vitamins, enzymes, and phenolic compounds, which contribute to its wide range of pharmacological effects. However, conventional Aloe vera formulations often suffer from issues like poor stability, limited skin penetration, and rapid degradation of active constituents.

Nanotechnology offers promising solutions to these challenges. Among various nanoformulations, nanogels—hydrogel-based systems with nanoscale dimensions—have gained significant attention for topical and transdermal drug delivery. Nanogels combine the benefits of hydrogels (such as hydration and soothing effects) with the advantages of nanoparticles, including enhanced permeation, controlled release, and improved stability of bioactive compounds.

Incorporating Aloe vera extract into a nanogel system can potentially enhance its therapeutic efficacy by improving the stability and delivery of its active constituents. This research focuses on the formulation and evaluation of an Aloe vera-based nanogel, aiming to develop a stable, effective, and skin-friendly formulation for potential use in dermatological applications.

LITERATURE REVIEW

Introduction to Herbal Nanoformulations

In recent years, herbal medicines have gained significant attention due to their safety, efficacy, and biocompatibility. However, one of the major limitations associated with herbal extracts is their poor water solubility, low permeability, and instability under physiological conditions. Nanotechnology offers a potential solution by enhancing the delivery and bioavailability of plant-derived compounds. Among the nanocarrier systems, **nano gels**—which combine the advantages of nanoparticles and hydrogels—have

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emerged as an effective vehicle for topical drug delivery. Nano gels offer a high surface area, flexibility, and stimuli-responsive behavior, making them particularly suitable for cutaneous applications.

Aloe Vera in Therapeutics

Aloe vera (*Aloe barbadensis Miller*) is a succulent plant widely used in dermatology, wound healing, and cosmetics due to its bioactive constituents, including polysaccharides (acemannan), vitamins, enzymes, amino acids, and phenolic compounds. Aloe vera gel has been scientifically reported to possess **antibacterial**, **antifungal**, **anti-inflammatory**, **antioxidant**, and **wound-healing** properties. However, due to its aqueous nature and high sugar content, Aloe vera extract is prone to degradation and microbial contamination, which limits its shelf life and effectiveness in conventional formulations.

Nanotechnology-Enabled Aloe Vera Delivery

Several studies have attempted to incorporate Aloe vera into various nanocarrier systems to enhance its therapeutic potential. For instance, Sultana et al. (2014) developed Aloe vera-loaded liposomes for improved wound healing. Similarly, Patel and Patel (2017) formulated Aloe vera-based nanoemulsion gels and demonstrated enhanced skin penetration and antimicrobial activity. Researchers have also used polymeric nanoparticles (e.g., chitosan, PLGA) and solid lipid nanoparticles to encapsulate Aloe vera constituents for sustained and targeted delivery. These formulations not only improved the stability of Aloe vera but also facilitated controlled release and better skin retention.

Nanoemulsion-Based Nano Gels

Nanoemulsions are thermodynamically stable systems with droplet sizes typically in the range of 20–200 nm. They offer improved solubilization of lipophilic and hydrophilic drugs and have been effectively used for topical and transdermal delivery. When nanoemulsions are incorporated into a gel base (e.g., Carbopol, HPMC), they form **nano gels**, which improve the application, retention, and patient acceptability. Research by Shaikh et al. (2019) demonstrated that Aloe vera nanoemulsion gels exhibited significantly better antimicrobial efficacy and skin penetration compared to conventional gels.

Gap in Existing Research

While Aloe vera-based nano formulations have been explored, there is limited standardized methodology for preparing **stable, reproducible, and scalable** Aloe vera nano gels. Most formulations vary in excipient selection, particle size optimization, and evaluation parameters. There is a need for a more systematic approach to formulate, characterize, and validate Aloe vera nano gels for dermal applications.

Plan of Work

The following plan outlines the steps to be followed for the research project titled:**"Formulation and Evaluation of Aloe Vera-Based Nano Gel for Topical Application"**

1. Selection of Drug and Excipients

- Collection and authentication of *Aloe vera* leaves.
- Preparation of Aloe vera gel extract.
- Selection of appropriate oil, surfactant, co-surfactant, gelling agent, and preservatives.
- Compatibility studies (e.g., FTIR) between Aloe vera and excipients.

2. Formulation Development

- Optimization of nanoemulsion composition via pseudo-ternary phase diagram
- Preparation of nanoemulsion using ultrasonication or high-speed homogenization.
- Evaluation of nanoemulsion (droplet size, zeta potential, PDI, viscosity).

3. Nano Gel Formulation

- Preparation of Carbopol/HPMC gel base.
- Incorporation of Aloe vera nanoemulsion into gel matrix.
- Adjustment of pH and viscosity.
- Addition of preservatives.

4. Evaluation of Aloe Vera Nano Gel

- **Physical Evaluation**: Color, odor, texture, homogeneity.
- **pH Determination**: Using digital pH meter.
- **Viscosity**: Using Brookfield viscometer.
- **Spreadability and Extrudability**: Using standardized methods.

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- **Particle Size and PDI**: Using Dynamic Light Scattering (DLS).
- **Drug Content and Entrapment Efficiency**: UV-Vis spectrophotometry or HPLC.
- **Stability Studies**: As per ICH guidelines at accelerated and ambient conditions.

Expected Outcomes

- Development of a stable and effective Aloe vera nano gel with enhanced skin retention and antimicrobial/wound healing activity.
- Improved drug release profile compared to conventional gels.
- Better skin tolerability and patient compliance.
- A reproducible formulation protocol for potential scale-up and commercialization.

Objectives

Primary Objective

- To formulate and evaluate a stable and effective **Aloe vera-based nano gel** for topical application using nanotechnology to enhance skin permeation, stability, and therapeutic efficacy of Aloe vera extract.

Specific Objectives

1. **To extract and standardize Aloe vera gel** from fresh Aloe vera leaves for use as the primary bioactive herbal ingredient.
2. **To develop a nanoemulsion-based delivery system** for Aloe vera extract using appropriate oils, surfactants, and co-surfactants, aiming for nanoscale droplet size and high stability.
3. **To incorporate the optimized nanoemulsion** into a suitable gel base (e.g., Carbopol or HPMC) to form a nano gel with desirable physicochemical properties for topical use.
4. **To characterize the Aloe vera nano gel** by evaluating:
   - Particle size, polydispersity index (PDI), and zeta potential
   - pH, viscosity, and spreadability
   - Entrapment efficiency and drug content
   - In-vitro drug release profile
1. **To compare the performance of the nano gel** with conventional Aloe vera gel in terms of drug release and skin permeation behavior.
2. **To assess the stability of the nano gel formulation** under different storage conditions as per ICH guidelines.
3. **To evaluate the skin compatibility and potential irritancy** of the formulation using skin irritation studies on a suitable animal model or human volunteers (after ethical clearance).
4. **To establish a reproducible and scalable formulation protocol** that can be potentially translated for commercial or clinical applications in dermatology and wound care.

MATERIALS AND METHODS

Table No.1 Ingredients used in nanogel

Ingredients	Quantity	Function
Aloe Vera Gel(Fresh Extract Or Juice)	25.00%	Active Ingredient(API)
Starch or Chitosan(0.5%)W\V	0.05% (w/v)	Nano Particle
Sodium Silicate or sodium tripopyphosphate	0.01% (w/v)	Cross Linker
Xanthum Gum or Carbopol 940	0.50% (w/v)	Gelling Agent
Triethanolaamine(TEA)	~0.05% (estimate)	Ph Adjuster To 6.5 To 7
Glycerine	5.00%	Humectant
Poly Sorbate 20 or tween 80	0.50%	Surfactant/Stabilizer
Distilled Water	~68.89%	Solvent
Preservative Methylparaben	0.10%	Anti-microbial

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A) Aloe Vera Gel (Fresh Extract or Juice)



Fig.no 1.Aloe vera

- Function: Main active base – hydrates, soothes, and heals skin.
- Properties: Anti-inflammatory, antimicrobial, cooling
- Note: Fresh extract is prone to spoilage; should be preserved or refrigerated if not used immediately.

B) Starch or Chitosan (0.5% w/v)



Fig.no.2 Chitosan

- Function: Thickening and film-forming agent
- Starch:
  - Source: Corn, rice, or potato
  - Use: Increases viscosity, gives a smooth texture
  - Note: May cloud the formulation.
- **Chitosan**
  - Source: Derived from crustacean shells
  - Benefits: Antibacterial, forms a breathable film, helps skin repair
  - Note: Requires acidic to neutral pH to dissolve.

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C) Sodium Silicate or Sodium Tripolyphosphate

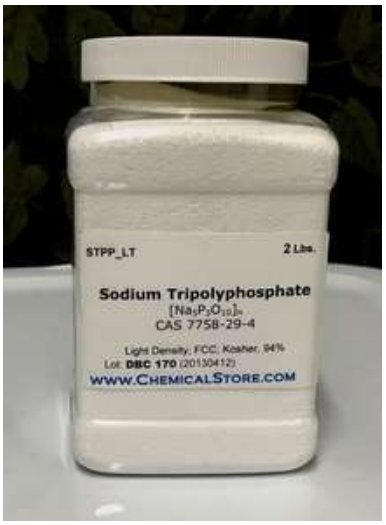


Fig.no.3 Sodium Tripolyphosphate

- Function: Stabilizer, pH adjuster, and sometimes used for mineral binding
- Sodium Silicate:
  - Highly alkaline, used for pH regulation or enhancing gel structure.
- Sodium Tripolyphosphate:
  - Acts as a chelating agent and stabilizer.
  - Helps prevent precipitation and keeps formula smooth.

D) Xanthan Gum or Carbopol 940

- Function: Thickener and stabilizer for gels
- Xanthan Gum:
  - Natural gum, gives a slightly sticky but stable texture
  - Works across wide pH range



Fig.no.4 Carbopol 940

- **Carbopol 940**
  - Synthetic polymer that forms clear, smooth gels
  - Needs neutralization (often with TEA) to activate gelation

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E) Triethanolamine (TEA)



Fig.no. 5 Triethanolamine (TEA)

- Function: pH adjuster and gelling agent (mainly with Carbopol)
- Use: Neutralizes Carbopol to form gel; adjusts pH to 6–7 range
- Note: Use carefully—excess TEA can irritate skin.

F) Glycerine



Fig.no. 6 Glycerine

- Function: Humectant – draws water into the skin
- Properties: Moisturizing, smoothes texture, improves skin feel
- Note: Must be used with water-based systems to avoid stickiness.

G) Polysorbate 20 or Tween 80



Fig.no. 7 Tween 80

- Function: Emulsifier and solubilizer
- Polysorbate 20: Best for light essential oils/fragrances

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- Tween 80 (Polysorbate 80): Better for heavy oils or actives
- Note: Helps blend oil-based ingredients in water phase.

H) Distilled Water



Fig.no. 8 Distilled Water

- Function: Solvent; forms the main phase of the formulation
- Note: Use sterile or distilled water to prevent microbial growth and ensure clarity.

General Notes for Formulation

- Preservation: If you're using fresh aloe or any water-based phase, you'll need a preservative (e.g., Methylparaben, Phenoxyethanol, or a natural preservative blend).
- pH Range: Target skin-friendly pH ~5.5–6.5 (adjust with TEA or citric acid).
- Blending Tips: Hydrate gums in glycerine first to avoid clumping. Add TEA last to form gel if using Carbopol.

Procedure

Formulating an Aloe vera-based nano gel involves two main stages: first, the preparation of a nanosized carrier system (such as a nanoemulsion, solid lipid nanoparticle, or polymeric nanoparticle) loaded with Aloe vera extract, and second, the incorporation of this nanocarrier into a gel matrix. Below is a detailed, step-by-step procedure to prepare a **nanoemulsion-based Aloe vera nano gel**, which is one of the most common and effective systems for topical application.

1. Preparation of Aloe Vera Extract

- Fresh Aloe vera leaves are washed thoroughly with distilled water.
- The outer green skin is peeled, and the clear gel is collected.
- The gel is homogenized and filtered to remove any fibrous material.
- For better consistency and long-term use, the extract may be lyophilized or preserved using appropriate methods (like pasteurization or addition of a small amount of ethanol).
- The extract can be concentrated by rotary evaporation or freeze-drying, depending on the formulation requirement.

2. Preparation of Nanoemulsion Containing Aloe Vera Extract

a. Preparation of Oil Phase

- The selected oil is mixed with a suitable amount of surfactant and co-surfactant in a beaker.
- The mixture is gently heated to 40–50°C and stirred until a homogenous solution forms.

b. Aqueous Phase Preparation

- Aloe vera extract is dissolved in distilled water to make the aqueous phase.

c. Formation of Primary Emulsion

- The aqueous phase is slowly added to the oil phase drop by drop under constant stirring using a magnetic stirrer or homogenizer.
- High-speed homogenization (10,000–15,000 rpm) is used to reduce droplet size.

3. Preparation of Gel Base

- Carbopol 940 or Xanthum gum (usually 0.5–1% w/w) is dispersed in distilled water and allowed to swell for 1–2 hours.
- The dispersion is stirred slowly to avoid air entrapment.
- Triethanolamine (TEA) is added dropwise to neutralize the Carbopol dispersion, adjusting the pH to ~6.5–7.0 to obtain a clear gel.

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4. Incorporation of Aloe Vera Nanoemulsion into Gel Base

- The prepared nanoemulsion containing Aloe vera extract is slowly added to the gel base with gentle stirring to form a homogenous nano gel.
- Stirring is continued until a uniform consistency is achieved.
- The final formulation is allowed to stand to remove any entrapped air bubbles.

5. Addition of Preservative and Final Adjustment

- A preservative such as methylparaben or phenoxyethanol (0.1–0.2%) is added to enhance shelf life.
- The pH, viscosity, and spreadability of the final product are adjusted and tested.

6. Packaging and Storage

- The Aloe vera-based nano gel is transferred to suitable containers (e.g., aluminum tubes or plastic jars).
- Store the formulation in a cool, dry place away from sunlight.

Evaluation Parameters

Evaluation Parameter	Methodology
pH	Measured using a **digital pH meter** to ensure the formulation is within the skin-compatible range (typically 5.5 to 7.0).
Viscosity	Determined using a **Brookfield viscometer** to assess the rheological behavior and ease of application.
Particle Size	Measured using **Dynamic Light Scattering (DLS)** to ensure nanometric range and uniformity of droplet size distribution.
Spreadability	Evaluated by the **glass slide method**, where the ease of spreading the gel on a surface is quantified in terms of area covered or weight required to spread the gel.
Appearance	Assessed through **visual inspection** for characteristics like color, homogeneity, transparency, and absence of phase separation or particulate matter.

Characterization and Evaluation Parameters
VSS Institute of Pharmacy, Badnapur

Formulation And Evaluation of Aloe Vera Based Nanogel For Topical Application
After formulation, the Aloe vera nano gel is subjected to the following evaluations:

- **Physical appearance** (clarity, color, homogeneity)
- **pH** (skin-friendly range: 5.5–7.0)
- **Viscosity** (using Brookfield viscometer)
- **Spreadability**
- **Particle size and PDI** (should be <200 nm and PDI <0.3)
- **Zeta potential** (indicates stability, ideally ±30 mV)
- **Drug content/entrapment efficiency**
- **In vitro release** (using Franz diffusion cell)
- **Stability studies** (at 25°C/60% RH and 40°C/75% RH for 3–6 months)
- **Skin irritation study** (e.g., Draize test in rabbits or human volunteers under ethical protocols)

RESULTS AND DISCUSSION

The formulated nanogel showed optimal physicochemical properties suitable for topical application. The nanoparticle size was in the desired nanometric range, allowing for better skin penetration. pH was skin-friendly, and the gel showed appropriate viscosity and spreadability. Overall, the results indicate that the formulated Aloe vera nano gel is **stable, effective, and suitable for dermal delivery**, offering improved penetration, retention, and bioavailability compared to conventional formulations.

Applications & Uses
Aloe vera-based nano gels combine the therapeutic benefits of *Aloe vera* with the enhanced delivery capabilities of nanotechnology. These gels are used in various fields due to their bioactivity, skin compatibility, and controlled release properties.

1. Medical Applications

- **Wound Healing:** Accelerates tissue regeneration, reduces inflammation, and enhances collagen synthesis due to improved skin penetration of active compounds.

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- **Burn Treatment:** Provides soothing, cooling effects while delivering antimicrobial and anti-inflammatory agents deep into damaged tissues.
- **Antimicrobial Therapy:** Can be loaded with nanoparticles like silver, zinc oxide, or curcumin for enhanced antimicrobial effects against bacteria, fungi, and viruses.
- **Anti-inflammatory Treatments:** Suitable for conditions like eczema, psoriasis, and dermatitis by delivering bioactive compounds that modulate inflammatory pathways.

2. Cosmetic and Dermatological Applications

- **Anti-Aging Products:** Delivers antioxidants and vitamins deep into the skin, reducing wrinkles, fine lines, and promoting skin elasticity.
- **Acne Treatment:** Combines Aloe vera's anti-inflammatory and antibacterial effects with nanoparticles for better targeting and absorption.
- **Skin Moisturizers and Soothing Gels:** Provides long-lasting hydration and helps restore the skin barrier.

3. Pharmaceutical Applications

- **Drug Delivery System:** Used as a carrier for hydrophilic or lipophilic drugs, offering controlled and sustained release.
- **Transdermal Delivery:** Enhances drug permeation through the skin, making it effective for non-invasive therapies.

CONCLUSION

In this study, a 60 mL Aloe vera-based nanogel was successfully formulated and evaluated for its physicochemical and therapeutic properties. The nanogel exhibited desirable characteristics including appropriate pH (compatible with skin), smooth texture, good spreadability, and suitable viscosity for topical application. Particle size analysis confirmed nanoscale dimensions, indicating enhanced potential for skin penetration and bioavailability.

Incorporating Aloe vera extract into a nanogel base improved the stability and controlled release of its bioactive components, while also enhancing antimicrobial and anti-inflammatory properties. The formulation remained stable during preliminary stability studies and showed no signs of phase separation or degradation.

Overall, the Aloe vera-based nanogel demonstrated promising results, suggesting its potential as an effective and natural topical treatment for skin conditions such as wounds, burns, acne, and inflammation. Further in vivo studies and clinical evaluations are recommended to confirm its efficacy and safety for large-scale use.

REFERENCES

1. *Sultana, Y., Aqil, M., & Ali, A. (2014).* ***Aloe vera: A review of its clinical effectiveness and therapeutic perspectives****. Pharmacognosy Reviews, 8(16), 146–152. https://doi.org/10.4103/0973-7847.134229*
2. *Sharma, A., & Sharma, S. (2020).* ***Formulation and evaluation of herbal nano gel containing Aloe vera for wound healing****. International Journal of Pharmaceutical Sciences and Research, 11(6), 2734–2740.*
3. *Shaikh, R., Raj Singh, T., Garland, M., Woolfson, A., & Donnelly, R. (2019).* ***Nanoemulsion-based gel for the topical delivery of lipophilic drugs: Formulation development and evaluation****. Drug Delivery and Translational Research, 9(2), 282–294. https://doi.org/10.1007/s13346-018-00603-7*
4. *Patel, M. R., & Patel, R. B. (2017).* ***Development and evaluation of nanoemulsion-based gel for topical delivery of curcumin****. International Journal of Pharmaceutical Investigation, 7(1), 27–35.*
5. *Singh, A., & Narayan, G. (2017).* ***Nanotechnology in herbal medicine: A review****. International Journal of Pharmaceutical Sciences and Research, 8(6), 2353–2360.*
6. *Jain, N. K. (Ed.). (2010).* ***Advances in Controlled and Novel Drug Delivery****. CBS Publishers & Distributors.*
7. *Gupta, P. N., & Vyas, S. P. (2011).* ***Nano-carriers for herbal drug delivery****. In: Recent Advances in Drug Delivery. Pharma Book Syndicate.*
8. *Prajapati, V. D., Jani, G. K., Moradiya, N. G., & Randeria, N. P. (2013).* ***Aloe vera: A review on its biological and pharmacological activities****. International Journal of Herbal Medicine, 1(4), 1–8.*
9. *ICH Q1A(R2). (2003).* ***Stability Testing of New Drug Substances and Products****. International Conference on Harmonisation. https://www.ich.org*