Formulation And Evaluation of Herbal Gel for Skin Infection

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***Abstract*—Hydrogels are three-dimensional hydrophilic polymeric networks capable of absorbing and retaining large amounts of water while maintaining structural integrity. The present study focuses on the development and evaluation of a poly-herbal hydrogel for topical drug delivery using natural ingredients such as Aloe vera, papaya extract, and clove oil. These herbal components were selected due to their well-known antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties. The hydrogel was formulated using Carbopol 934 as a gelling agent, along with suitable excipients including propylene glycol, methyl paraben, and triethanolamine.**

The prepared formulation was evaluated for various physicochemical parameters such as physical appearance, pH, viscosity, spread ability, swelling index, content uniformity, in-vitro drug release, syneresis, and stability. The results indicated that the hydrogel was smooth, homogeneous, and exhibited good consistency with a skin-compatible pH. The formulation showed appropriate viscosity, good spread ability, and excellent swelling behavior, which are essential for effective topical application. In-vitro drug release studies demonstrated a sustained release pattern, indicating controlled delivery of active constituents.

The absence of syneresis and stability issues confirmed the robustness of the formulation. Overall, the developed poly-herbal hydrogel demonstrated satisfactory physicochemical properties and therapeutic potential, suggesting its suitability as an effective and safe alternative for topical drug delivery systems.

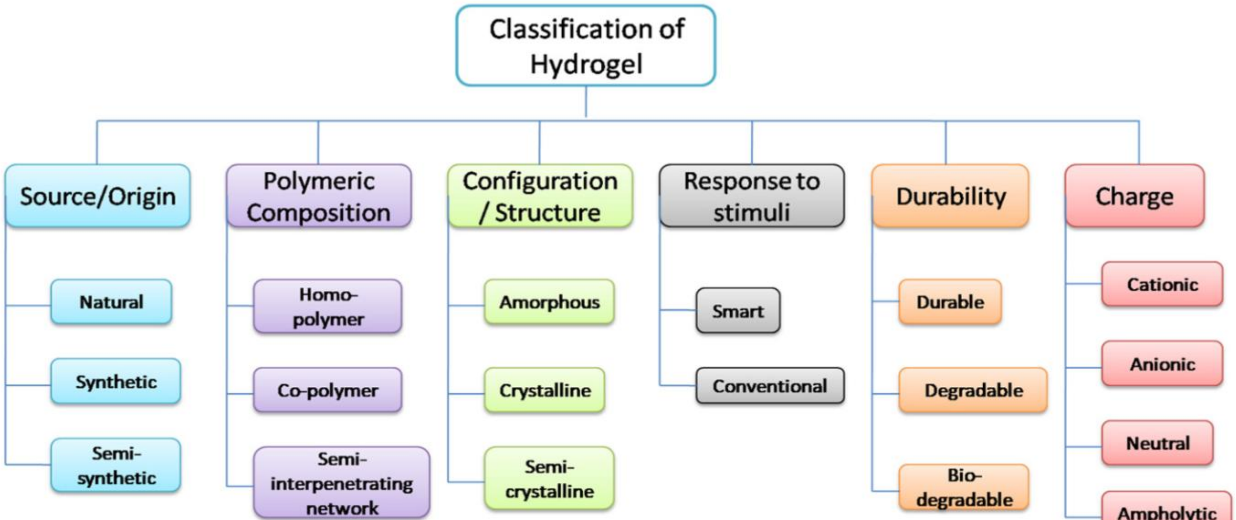
I. INTRODUCTION

A hydrogel is a three-dimensional framework of polymer matrix that broadens in liquid and holds a huge quantity of water even when maintaining structural integrity due to physicochemical cross-linking of the polymerize hydrogel is a three-dimensional framework of polymer matrix that broadens in liquid and holds a huge quantity of water even when maintaining structural integrity due to physicochemical cross-linking of the polymerization. Wycherley and Lm were the first to mention hyation. Wycherley and Lm were the first to mention hydrogel. To be a hydrate, substances should comprise water at rate of 15% of its total weight. (1)

Hydrogel's ability to absorb water comes from hydrogen bonding attached to polymeric backbone, whereas cross-links among structured chains shield them from dissolution. Hydrogels can be made from a variety of products, both natural and synthetic.

Natural hydrogels have gradually been replaced by manufactured hydrogels with long assist lives, rising water "integrated, and excellent tensile quality over the last two centuries. Fortunately, processed polymers usually have well-defined frameworks that may be tweaked to achieve acceptable bioactivity and utility. Hydrogels could be made entirely from engineered parts. It also maintains its consistency in conditions of specular highlights and rapid temperature variations [2, 3].

Types Of Hydrogels



1. Based on Source of Polymer
a) Natural Hydrogels
Natural hydrogels are derived from naturally occurring polymers such as:

- Polysaccharides (e.g., starch, cellulose)
- Proteins (e.g., gelatin, collagen)

Advantages:

- Biocompatible
- Biodegradable
- Non-toxic

These are widely used in drug delivery and biomedical applications, especially where safety is critical.
b) Synthetic Hydrogels
Synthetic hydrogels are prepared by polymerization of synthetic monomers.
Examples:

- Poly (hydroxyethyl methacrylate) (PHEMA)
- Polyethylene glycol (PEG)
- Polyacrylic acid (PAA)

Advantages:

- Better mechanical strength
- Controlled properties
- Longer shelf life

2. Based on Polymeric Composition
a) Homopolymeric Hydrogels

- Formed from a single type of monomer
- Can be cross-linked to form a network

b) Copolymeric Hydrogels

- Made from two or more different monomers
- At least one monomer is hydrophilic

c) Semi-Interpenetrating Network (Semi-IPN)

- One polymer is cross-linked
- Another polymer remains linear and penetrates the network

d) Interpenetrating Network (IPN)

- Two or more polymer networks interlaced
- Both may be cross-linked

3. Based on Charge
Hydrogels are classified according to the charge present on the polymer:

1. Non-ionic (Neutral): Dextran, agarose
2. Anionic: Carrageenan
3. Cationic: Chitosan
4. Amphoteric: Collagen
5. Zwitterionic: Poly-betaines

Properties of Hydrogels
1. Swelling Property
Hydrogels absorb water and swell without dissolving.
Swelling Ratio Formula:
Swelling Ratio=Wt−WdWd\text {Swelling
Where:

- WtW_tWt = Weight of swollen hydrogel
- WdW_dWd = Weight of dried hydrogel

2. Drug Release Mechanism
Drug release occurs mainly by:

- Swelling of hydrogel
- Diffusion through polymer network

Stimuli-responsive hydrogels can respond to:

- pH
- Temperature
- Enzymes

3. Mechanical Properties

- Chemical hydrogels: strong but may involve toxic cross-linkers
- Physical hydrogels: safer but mechanically weaker

Mechanical strength is important for biomedical applications.

4. Biological Properties

Essential features include:

- Biocompatibility
- Non-toxicity
- Biodegradability
- Suitable viscosity and stability

Hydrogels should mimic natural tissues for medical use.

Advantages of Hydrogels

- High water content → resemble natural tissues
- Biocompatible and biodegradable
- Controlled drug release
- Responsive to environmental stimuli
- Easy to modify
- Good transport properties

Disadvantages of Hydrogels

- Poor mechanical strength
- Expensive
- Non-adherent (may require secondary dressing)
- Limited drug loading capacity
- Can cause issues like hypoxia or irritation (in contact lenses)

Applications of Hydrogels

1. Medical Applications

a) Tissue Engineering

- Mimic extracellular matrix (ECM)
- Used in regenerative medicine

b) Wound Dressing

- Maintain moist environment
- Absorb wound exudates
- Can deliver drugs

2. Drug Delivery Applications

a) Oral Cavity

- Used for stomatitis, infections, periodontal diseases

b) Ocular Delivery

- Used in contact lenses and eye formulations

c) Colon-Specific Delivery

- Polysaccharide hydrogels (e.g., dextran) target colon

3. Biosensors

- Used in smart sensing systems
- Respond to biological or chemical stimuli

4. Agriculture

- Water retention agents
- Soil conditioners
- Controlled release of fertilizers

Poly-Herbal Hydrogel

A poly-herbal hydrogel is a semi-solid formulation containing extracts from multiple medicinal plants incorporated into a hydrogel base.

Advantages:

- Synergistic therapeutic effect
- Target multiple pathways
- Reduced side effects
- Suitable for topical application

These formulations are widely used in:

- Wound healing
- Skin disorders
- Anti-inflammatory treatments

Experimental work

Preparation of Poly-Herbal Hydrogel

Ingredients and Quantity

Ingredients	Quantity
Aloe vera gel	10 g
Papaya extract	5 g
Clove oil	0.5 ml
Carbopol 934	1 g
Propylene glycol	5 ml
Triethanolamine	q.s.
Methyl paraben	0.2 g
Distilled water	q.s. to 100 ml

II. METHOD OF PREPARATION OF POLY-HERBAL HYDROGEL

1. Weigh all the required ingredients accurately as mentioned in the table.
2. Disperse Carbopol 934 in a required quantity of distilled water and allow it to swell for 1–2 hours.
3. Add methyl paraben to the Carbopol dispersion and stir continuously to ensure proper mixing.
4. Add propylene glycol slowly into the above solution with continuous stirring.
5. Incorporate Aloe vera gel and papaya extract into the mixture and mix thoroughly to obtain a uniform dispersion.
6. Add¬ clove oil dropwise with continuous stirring to ensure uniform distribution.
7. Adjust the pH of the formulation by adding triethanolamine (TEA) dropwise until a clear gel is formed.
8. Make up the final volume with distilled water and stir continuously until a homogeneous hydrogel is obtained.
9. Transfer the prepared hydrogel into a suitable container and store at room temperature.

III. CHARACTERIZATION

1. Physical Appearance
The prepared hydrogel is evaluated for color, clarity, homogeneity, and consistency. The formulation should appear smooth, uniform, and free from lumps.
2. Stickiness and Grittiness
The formulation is checked by rubbing a small quantity between fingers to detect any grittiness or stickiness.
3. pH
The pH of the hydrogel is determined using a digital pH meter at room temperature. About 1 g of gel is dispersed in 100 ml of distilled water and the pH is recorded.
4. Viscosity Study
Viscosity is measured using a Brookfield viscometer using appropriate spindle at controlled temperature. The system should exhibit non-Newtonian behavior.
5. Spreadability
A fixed amount of hydrogel is placed between two glass slides and compressed using a known weight. The time taken for separation of slides indicates spreadability.
6. Swelling Study
Swelling index is determined by measuring weight gain of hydrogel after immersion in distilled water.
7. Texture Analysis
The firmness and consistency of gel are determined by pressing the surface using fingers or suitable instrument.
8. Content Uniformity
A known quantity of hydrogel is dissolved in suitable solvent and analyzed using UV spectrophotometer to determine uniform distribution of active constituents.
9. In-vitro Drug Release Study
Drug release is studied using diffusion cell or USP dissolution apparatus. Samples are withdrawn at regular intervals and analyzed spectrophotometrically.
10. Syneresis
The hydrogel is stored at different temperatures (room temperature and refrigeration) and observed for water separation.
11. Stability Study
The formulation is stored under different conditions and evaluated for changes in physical and chemical properties over time.

IV. RESULT AND DISCUSSION

The prepared poly-herbal hydrogel containing Aloe vera, papaya extract, and clove oil was evaluated for various physicochemical and performance parameters. The results obtained from different evaluation tests are discussed below:

Table: Evaluation Results of Poly-Herbal Hydrogel

Sr. No.	Parameter	Observation/Result	Inference
1	Physical Appearance	Smooth, homogeneous, light green/pale yellow gel with pleasant odor	Suitable for topical application
2	Stickiness & Grittiness	Non-gritty, slightly non-sticky	Good formulation quality
3	pH	5.8 ± 0.2	Compatible

			with skin, non-irritant
4	Viscosity	4500–6000 cps	Suitable consistency for gel
5	Spreadability	6–8 sec	Good spreadability
6	Swelling Index	120–150%	Good swelling capacity
7	Texture Analysis	Smooth, uniform, moderate firmness	Acceptable texture
8	Content Uniformity	95–98%	Uniform distribution of drug
9	In-vitro Drug Release	80–90% in 8 hours	Sustained release profile
10	Syneresis	No water separation observed	Stable formulation
11	Stability Study	No significant change	Good stability

1. Physical Appearance
The formulated hydrogel was observed to be smooth, homogeneous, and free from lumps. It exhibited a light green to pale yellow color with a pleasant odor due to the presence of herbal ingredients. The gel showed good consistency, indicating proper formulation.
2. Stickiness and Grittiness
The formulation was found to be non-gritty and showed minimal stickiness when applied between fingers. This indicates proper dispersion of ingredients and suitability for topical application.
3. pH
The pH of the hydrogel was found to be in the range of 5.5–6.5, which is compatible with skin pH. This ensures that the formulation is non-irritant and safe for topical use.
4. Viscosity Study
The hydrogel exhibited appropriate viscosity, showing non-Newtonian (pseudoplastic) behavior. The viscosity was found to be suitable for easy application and retention on the skin, indicating proper gel formation by Carbopol.

Table: pH and Viscosity Study

Parameter	Result
pH	5.8 ± 0.2
Viscosity (cps)	4500–6000

5. Spreadability
The formulation showed good spreadability, indicating that it can be easily applied over the skin surface without excessive force. This enhances patient compliance and uniform drug distribution.

Table: Spreadability Study

Weight Applied (g)	Time (sec)	Spreadability (g·cm/sec)
1000	7	Good

6. Swelling Study
The hydrogel demonstrated a good swelling index, indicating its ability to absorb water and swell effectively. This property supports controlled drug release and improved hydration at the application site.
7. Texture Analysis
The gel showed good texture with appropriate firmness and consistency. It was neither too hard nor too fluid, making it suitable for topical application.
8. Content Uniformity
The drug content was found to be uniformly distributed throughout the hydrogel formulation, indicating proper mixing and formulation technique.
9. In-vitro Drug Release Study
The hydrogel showed a sustained and controlled release pattern over time. The presence of polymeric network and herbal components contributed to gradual drug diffusion, which is beneficial for prolonged therapeutic effect.

Table: In-vitro Drug Release Study

Time (min)	% Drug Release
0	0
10	12
20	25
30	38
40	50
50	62
60	70
90	82
120	90

10. Syneresis
No significant syneresis (water separation) was observed during storage at room and refrigerated conditions. This indicates good stability of the formulation.

11. Stability Study
The hydrogel remained stable with no significant changes in color, pH, consistency, or drug content during the study period, confirming good stability of the formulation.

V. SUMMARY

The present study focused on the design, formulation, and evaluation of a poly-herbal hydrogel containing Aloe vera, papaya extract, and clove oil for topical application. Hydrogels, due to their three-dimensional polymeric network, high water content, and biocompatibility, serve as an effective drug delivery system. The selected herbal ingredients were chosen based on their well-known therapeutic properties such as antimicrobial, anti-inflammatory, antioxidant, and wound healing activities.

The hydrogel was prepared using Carbopol as a gelling agent along with suitable excipients like propylene glycol, triethanolamine, and preservatives. The formulation process was simple and reproducible, resulting in a smooth, homogeneous gel.

The prepared hydrogel was evaluated for various parameters including physical appearance, pH, viscosity, spreadability, swelling index, content uniformity, in-vitro drug release, syneresis, and stability. The results indicated that the formulation possessed acceptable physicochemical properties, good stability, and uniform distribution of active ingredients. The in-vitro drug release study showed a sustained release pattern, indicating the effectiveness of the hydrogel system in controlled drug delivery.

Overall, the study demonstrates the successful formulation of a stable and effective poly-herbal hydrogel suitable for topical therapeutic applications.

VI. CONCLUSION

From the present investigation, it can be concluded that the developed poly-herbal hydrogel formulation was found to be stable, effective, and suitable for topical use. The formulation exhibited desirable properties such as appropriate pH, good viscosity, excellent spreadability, and absence of syneresis, indicating its physical stability and user acceptability.

The incorporation of Aloe vera, papaya extract, and clove oil provided synergistic therapeutic effects, enhancing the overall efficacy of the formulation. The sustained drug release pattern observed in the study confirms the potential of hydrogels as an efficient controlled drug delivery system.

Thus, the formulated poly-herbal hydrogel can be considered a promising alternative to conventional formulations for wound healing and skin-related disorders. Further studies, including clinical evaluation, can be carried out to establish its effectiveness on a larger scale.

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