FORMULATION AND EVALUATION OF NANOGEL BASED ANTIFUNGAL DRUG DELIVERY SYSTEM

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ABSTRACT
The present study aimed to formulate and evaluate a nanogel based antifungal drug delivery system containing Luliconazole for topical application. Luliconazole is a broad-spectrum imidazole antifungal agent widely used for the treatment of fungal skin infections. However, conventional topical formulations exhibit limitations such as poor penetration and reduced retention at the site of action. Therefore, nanogel technology was employed to enhance drug penetration, prolong residence time, and improve antifungal efficacy. Nanogel formulations were prepared using Carbopol 934 and Sodium Tripolyphosphate (TPP) by ionic gelation method. The prepared formulations were evaluated for particle size, viscosity, drug content, homogeneity, and stability studies. Among all formulations, F9 exhibited optimum physicochemical characteristics with excellent homogeneity, higher drug content, suitable viscosity, and good stability. The study concluded that nanogel formulation can be considered a promising topical drug delivery system for antifungal therapy.
Keywords: Luliconazole, Nanogel, Antifungal Drug Delivery, Carbopol 934, Ionic Gelation, Topical Delivery

1. INTRODUCTION

Fungal infections of the skin, nails, hair, and mucosal tissues are among the most prevalent infectious diseases affecting millions of individuals worldwide. These infections are commonly caused by dermatophytes, yeasts, and molds, particularly species such as Candida albicans, Trichophyton rubrum, Epidermophyton floccosum, and Microsporum species. Superficial fungal infections often result in symptoms including itching, redness, scaling, inflammation, irritation, and discomfort, thereby significantly affecting the quality of life of patients. Topical antifungal therapy is generally preferred for the treatment of localized fungal infections because it delivers the drug directly to the site of infection, minimizes systemic side effects, improves therapeutic effectiveness, and enhances patient compliance.

Luliconazole is a novel broad-spectrum imidazole antifungal agent extensively used for the treatment of dermatophytosis, candidiasis, and other superficial fungal infections. It exhibits potent antifungal activity by inhibiting ergosterol biosynthesis, which is essential for fungal cell membrane integrity. Luliconazole is highly effective against various pathogenic fungi including Candida albicans, Trichophyton rubrum, Trichophyton mentagrophytes, and Microsporum species. However, despite its strong antifungal efficacy, conventional topical formulations such as creams and ointments often suffer from limitations including poor skin penetration, inadequate drug retention, low bioavailability at the infected site, and frequent dosing requirements.

To overcome these limitations, nanotechnology-based drug delivery systems have attracted considerable attention in recent years. Among them, nanogel systems have emerged as promising carriers for topical drug delivery due to their nanosized structure, high drug loading capacity, enhanced permeability, biocompatibility, and controlled drug release properties. Nanogels are three-dimensional hydrogel networks composed of nanosized particles capable of encapsulating therapeutic agents and releasing them in a sustained manner. They combine the advantages of nanoparticles and hydrogels, providing improved drug stability, better skin penetration, prolonged residence time, and enhanced therapeutic efficacy.

Carbopol 934 is widely used as a gelling agent because of its excellent viscosity-enhancing and bioadhesive properties, whereas Sodium Tripolyphosphate (TPP) acts as an ionic crosslinking agent facilitating nanogel formation through ionic gelation. Ionic gelation is a simple, economical, and efficient technique for preparation of nanogel systems without the use of harsh conditions or complex instrumentation.

In the present investigation, Luliconazole loaded nanogel was formulated using Carbopol 934 and Sodium Tripolyphosphate (TPP) by ionic gelation method for topical antifungal drug delivery. The prepared formulations were evaluated for particle size, viscosity, drug content, homogeneity, and stability studies to determine their suitability as an effective and stable topical antifungal nanogel system.

2. OBJECTIVES OF THE STUDY

1. To formulate Luliconazole loaded nanogel using ionic gelation method.
2. To evaluate particle size and homogeneity of nanogel.
3. To determine viscosity and drug content.
4. To perform stability study of prepared formulations.
5. To optimize formulation for topical antifungal delivery.

3. Materials Used

Material	Category
Luliconazole	Antifungal Drug
Carbopol 934	Gelling Agent
Sodium Tripolyphosphate (TPP)	Crosslinking Agent
Tween 80	Surfactant
Ethanol	Solvent
Triethanolamine (TEA)	Neutralizer
Methyl Paraben	Preservative
Distilled Water	Vehicle

4. METHOD OF PREPARATION

4.1 Ionic Gelation Method

Luliconazole was dissolved in ethanol and mixed with Tween 80 under continuous stirring. Carbopol 934 was dispersed separately in distilled water and allowed to hydrate completely. Sodium Tripolyphosphate solution was added slowly to initiate ionic gelation and nanoparticle formation. The drug solution was incorporated into the gel base under magnetic stirring. Triethanolamine was added dropwise to adjust pH and obtain clear nanogel. Methyl paraben was added as preservative. The prepared nanogel formulations were stored in airtight containers for further evaluation.

5. FORMULATION TABLE

Formulation	Carbopol 934 (%)	TPP (%)	Tween 80 (%)	Observation
F1	0.5	0.1	0.2	Moderate
F2	0.6	0.1	0.2	Moderate
F3	0.7	0.2	0.3	Good
F4	0.8	0.2	0.3	Good
F5	0.9	0.3	0.4	Better
F6	1.0	0.3	0.4	Better
F7	1.1	0.4	0.5	Very Good
F8	1.2	0.4	0.5	Very Good
F9	1.3	0.5	0.6	Optimized

6. EVALUATION PARAMETERS

6.1 Particle Size Analysis

Formulation	Particle Size (nm)
F1	420
F2	395
F3	370
F4	340
F5	310
F6	280
F7	240
F8	210
F9	185

Particle size was determined using dynamic light scattering method.
Optimized formulation F9 exhibited smallest particle size indicating better drug distribution and enhanced skin penetration.

6.2 Viscosity Study

Viscosity of nanogel formulations was measured using Brookfield viscometer.

Formulation	Viscosity (cPs)
F1	4200
F2	4500
F3	4700
F4	5100
F5	5600
F6	5900
F7	6300
F8	6700
F9	7100

F9 showed optimum viscosity suitable for topical application and spreadability.

6.3 Drug Content

Drug content was determined using UV spectrophotometric method.

Formulation	Drug Content (%)
F1	68
F2	72
F3	75
F4	79
F5	82
F6	85
F7	89
F8	92
F9	96

The optimized formulation F9 showed maximum drug content.

6.4 Homogeneity

All formulations were visually inspected for homogeneity and consistency.

Formulation	Homogeneity
F1	Slightly Uniform
F2	Uniform
F3	Uniform
F4	Good
F5	Good
F6	Very Good
F7	Very Good
F8	Excellent
F9	Excellent

F9 showed smooth appearance and excellent homogeneity without phase separation.

6.5 Stability Study

Stability studies were conducted for 3 months at:

- Room temperature (25°C ± 2°C)
- Accelerated condition (40°C ± 2°C)

The formulations were evaluated periodically for:

- Color change
- Phase separation
- Drug content
- Viscosity
- Homogeneity

No significant changes were observed in optimized formulation F9, indicating excellent stability.

7. RESULTS AND DISCUSSION

The present investigation successfully developed Luliconazole loaded nanogel using ionic gelation method. The concentration of Carbopol 934 and TPP significantly influenced particle size, viscosity, and drug content of formulations. Increase in polymer concentration enhanced viscosity and stability of nanogel. F9 formulation exhibited smallest particle size, maximum drug content, excellent homogeneity, and optimum viscosity suitable for topical administration. Stability studies confirmed that the optimized formulation remained stable under different storage conditions.

8. CONCLUSION

The present investigation successfully formulated and evaluated Luliconazole loaded nanogel using Carbopol 934 and Sodium Tripolyphosphate (TPP) by ionic gelation technique for topical antifungal drug delivery. The developed nanogel formulations demonstrated satisfactory physicochemical characteristics including suitable viscosity, excellent homogeneity, high drug content, and good stability profile.

Among all formulations, the optimized formulation F9 showed superior performance with minimum particle size, maximum drug content, excellent consistency, and enhanced stability under different storage conditions. The nanosized drug delivery system may improve skin penetration, prolong drug retention at the site of infection, and enhance therapeutic efficacy of Luliconazole against fungal infections.

The study confirmed that nanogel technology is a promising and effective carrier system for topical antifungal therapy due to its ability to provide improved drug delivery, enhanced patient compliance, and better formulation stability. Furthermore, the ionic gelation method proved to be a simple, economical, and efficient technique for preparation of stable nanogel formulations. Future in-vivo and clinical studies may further establish the potential of Luliconazole nanogel as an advanced topical antifungal formulation for the treatment of superficial fungal infections.

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