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RESEARCH ARTICLE
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FORMULATION AND EVALUATION OF HERBAL NAIL LACQUER FOR TREATMENT OF ONYCHOMYCOSIS

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Abstract

Onychomycosis is a common fungal infection of the nails characterized by discoloration, thickening, brittleness, and deformation of the nail plate. Conventional antifungal treatments may require prolonged therapy and can be associated with adverse effects and poor patient compliance. The present study was aimed at the formulation and evaluation of a herbal nail lacquer for the treatment of onychomycosis. Selected herbal extracts possessing potential antifungal properties were incorporated into a suitable nail lacquer base. The prepared formulations were evaluated for various physicochemical parameters such as appearance, colour, homogeneity, pH, viscosity, drying time, spread ability, film-forming ability, and adhesion to the nail surface. The antifungal activity of the formulations was evaluated against suitable fungal organisms responsible for onychomycosis. The optimized formulation exhibited satisfactory physical characteristics, good film-forming and adhesion properties, and promising antifungal activity. The formulation was able to form a uniform film over the nail surface, which may provide prolonged contact and localized delivery of herbal constituents. The study indicates that herbal nail lacquer may serve as a promising topical approach for the management of onychomycosis. Further stability, safety, in-vivo, and clinical studies are required to establish its therapeutic effectiveness and safety.

Keywords: Onychomycosis; Fungal nail infection; Herbal nail lacquer; Herbal extracts; Antifungal activity; Topical drug delivery; Nail plate; Film-forming ability; Localized drug delivery; Nail adhesion; Phytoconstituents; Antifungal formulation; Nail lacquer formulation;Topical therapy; Fungal infection

Research Gap And Rationale

Research Gap

Onychomycosis presents a formulation challenge because the nail plate is a dense keratinized barrier. Conventional topical dosage forms may have limited residence time and penetration, whereas oral antifungal therapy can involve systemic exposure and prolonged treatment. Published work has explored medicated nail lacquers, film-forming polymers, permeation enhancement and herbal/essential-oil approaches. The submitted literature review also cites work on transungual delivery, herbal nail lacquers and antifungal nail lacquer systems. A clear research gap for the present student project is the development and preliminary evaluation of a film-forming herbal nail lacquer using the selected oils and polymeric base described in the submitted formulation table, followed by physicochemical evaluation, in-vitro diffusion/release and antifungal assessment.

Rationale of the Study

Neem oil and tea tree oil were selected as herbal antifungal components in the submitted formulation. Castor oil and jojoba oil form part of the oil phase, while ethyl cellulose and HPMC provide the film-forming polymeric system. Propylene glycol and glycerin function as formulation excipients/plasticizing or humectant components as described in the submitted materials section. The objective is to obtain a uniform, adherent film capable of maintaining local contact with the nail surface.

Preformulation Studies

Prior to formulation development, preformulating studies were performed to evaluate the physicochemical characteristics of the selected herbal extract and its compatibility with the proposed excipients.

1. Organoleptic evaluation: The herbal extract was evaluated for colour, odour, appearance, and physical nature.
2. Solubility studies: The solubility of the herbal extract was determined in different solvents, including water, ethanol, methanol, and other solvents suitable for nail lacquer formulation.
3. pH determination: The pH of the herbal extract was determined using a calibrated digital pH meter.
4. Moisture content: Moisture content was determined to assess the stability and quality of the herbal extract.
5. Phytochemical screening: The extract was subjected to preliminary phytochemical screening for the presence of alkaloids, flavonoids, tannins, phenolic compounds, terpenoids, saponins, and other relevant phytoconstituents.
6. Extractive value: Extractive values were determined using appropriate solvents to estimate the amount of soluble constituents present in the herbal material.
7. Drug–excipient compatibility study: The compatibility of the herbal extract with selected excipients was evaluated by observing changes in colour, odour, appearance, precipitation, or other physical incompatibilities. FTIR/DSC may be included if these instruments are available.

8. Preliminary film-forming study: Different film-forming agents and concentrations were screened to identify a suitable polymer capable of producing a uniform, smooth, adherent, and rapidly drying film on the nail surface.
9. Stability of extract: The herbal extract was observed under suitable storage conditions for changes in colour, odour, consistency, and other physical characteristics.

Introduction

The nail is a highly keratinized structure that protects the distal phalanges of the fingers and toes. Although it serves as an effective physical barrier, its dense keratin network also limits the penetration of therapeutic agents. Nail disorders such as onychomycosis, paronychia, leukonychia, nail psoriasis, and brittle nail syndrome are common conditions that affect millions of people worldwide.

Conventional treatment of nail diseases primarily involves oral antifungal therapy or topical preparations such as creams, gels, and ointments. Oral therapy often provides effective drug concentrations but is associated with systemic adverse effects, drug interactions, prolonged treatment duration, and poor patient compliance. Conversely, conventional topical formulations are rapidly removed by washing or friction and exhibit poor penetration through the compact keratinized nail plate, resulting in inadequate therapeutic efficacy.

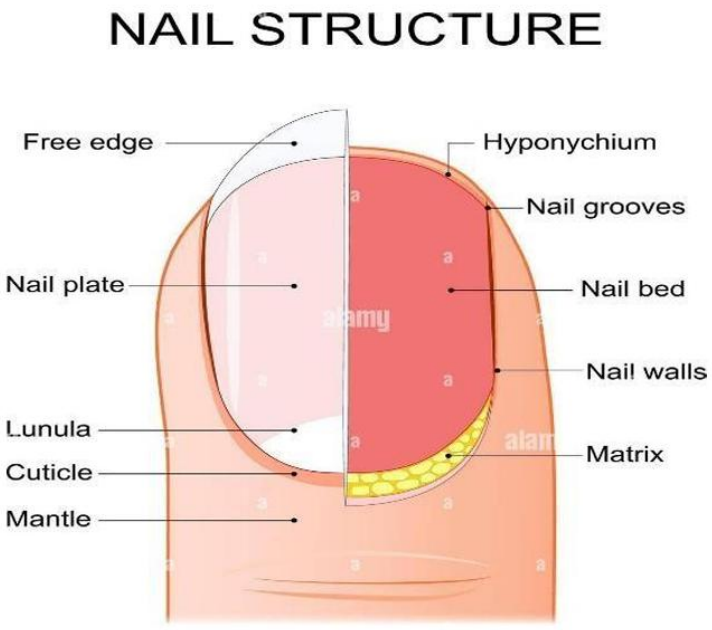


Fig:1

Transungual drug delivery has emerged as a promising strategy for the management of nail disorders by delivering therapeutic agents directly through the nail plate to the site of infection. Among the available transungual dosage forms, medicated nail lacquers have attracted considerable attention because they form a thin, transparent, adhesive polymeric film upon solvent evaporation. This film acts as a drug reservoir, ensuring prolonged contact with the nail surface, sustained drug release, improved patient compliance, and reduced systemic exposure.

The effectiveness of nail lacquer formulations depends on several formulation variables, including the selection of film-forming polymers, solvents, plasticizers, permeation enhancers, and active pharmaceutical ingredients. Since the nail plate has low water and lipid content, penetration enhancers and keratolytic agents are frequently incorporated to increase nail hydration, disrupt keratin cross-linking, and facilitate drug diffusion across the nail plate.

In recent years, there has been growing interest in herbal nail lacquers owing to the increasing demand for safer, naturally derived therapeutic products. Plant-derived oils and extracts possess antifungal, antibacterial, anti-inflammatory, antioxidant, and wound-healing properties while exhibiting minimal toxicity and fewer adverse effects compared with synthetic drugs. Herbal ingredients such as neem oil, tea tree oil, castor oil, clove oil, oregano oil, thyme oil, garlic extract, and turmeric extract have demonstrated promising activity against nail pathogens and contribute to improved nail health.

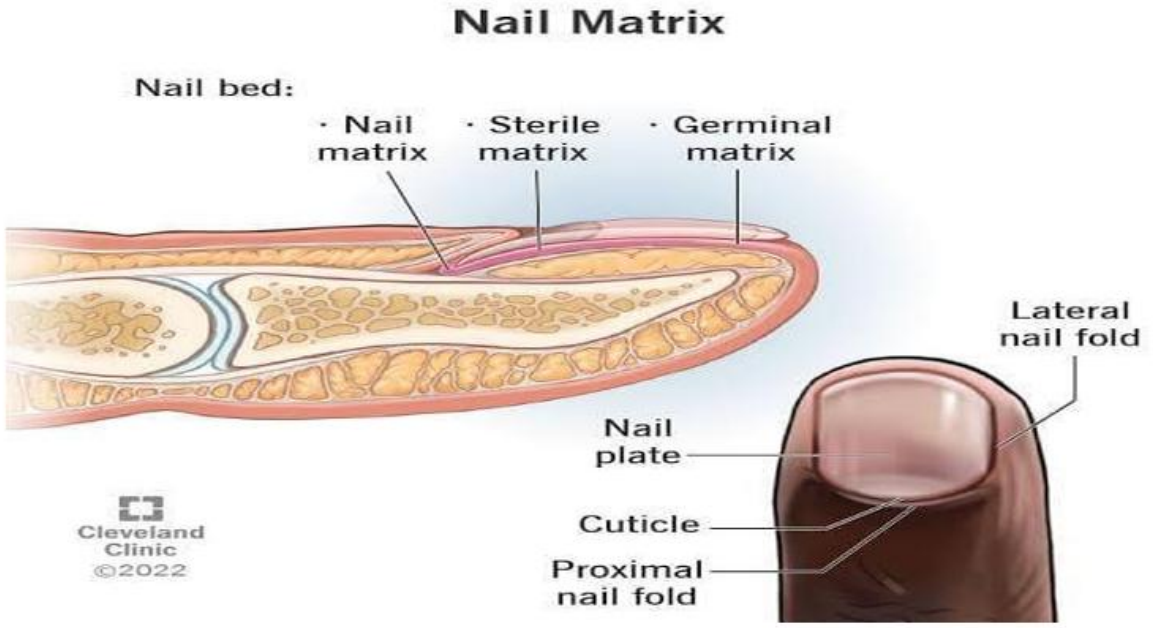


Fig:2

Nail Lacquer

Nail lacquer is a topical film-forming pharmaceutical dosage form designed for application on the nail plate to deliver therapeutic agents directly to the nail and surrounding tissues. After application, the volatile solvents evaporate, leaving a thin, transparent, adhesive polymeric film that serves as a drug reservoir. The drug is gradually released from the film and penetrates through the keratinized nail plate to produce a sustained therapeutic effect. Nail lacquers are primarily used for the treatment of nail disorders such as onychomycosis, nail psoriasis, paronychia, and other fungal or bacterial infections. Compared with conventional topical preparations, medicated nail lacquers provide prolonged contact time, improved drug penetration, reduced systemic side effects, and better patient compliance.



Fig. 3
History Of Nail Lacquer

The development of nail lacquer has evolved from a cosmetic product to an advanced pharmaceutical drug delivery system.

1. Ancient period (3000–5000 BC): Natural substances such as henna, beeswax, gum, egg white, and plant extracts were used in Egypt, China, and India to decorate and protect nails.
2. Early 20th century: Modern cosmetic nail polish was introduced using nitrocellulose based film-forming technology inspired by automobile paint formulations.
3. 3.1950s–1970s: Nail polish formulations were improved with better polymers, plasticizers, and solvents to enhance durability, gloss, and adhesion.
4. 4.1980s–1990s: Researchers recognized the potential of nail polish as a vehicle for localized drug delivery through the nail plate, leading to the development of medicated nail lacquers.
5. 5.1990s: The first medicated antifungal nail lacquers containing amorolfine and ciclopirox were introduced for the treatment of onychomycosis.
6. 6.2000s–Present: Research has focused on incorporating novel polymers, permeation enhancers, nanotechnology, and natural bioactive compounds into nail lacquer formulations to improve transungual drug delivery and therapeutic outcomes.

Today, nail lacquer is widely recognized as an effective transungual drug delivery system for treating fungal infections, inflammatory nail disorders, and cosmetic nail conditions.

Classification Of Nail Lacquer

Nail lacquers can be classified based on different criteria.

A. Based On Purpose

1. Cosmetic Nail Lacquer Used to beautify and protect nails. Provides colour, gloss, and aesthetic appeal. Contains pigments, film-forming polymers, plasticizers, and solvents.
2. Medicated Nail Lacquer Contains active pharmaceutical ingredients. Used for treating nail diseases such as onychomycosis, nail psoriasis, and bacterial infections. Provides sustained drug release through the nail plate.

B. Based On Therapeutic Application

1. Antifungal Nail Lacquer Used for fungal nail infections. Examples: Ciclopirox, Amorolfine, Efinaconazoles, Clotrimazole, Terbinafine.
2. Antibacterial Nail Lacquer Used for bacterial nail infections. Examples: Mupirocin, Gentamicin.
3. Anti-inflammatory Nail Lacquer Used for inflammatory nail disorders such as nail psoriasis. Examples: Corticosteroids, Tacrolimus.
4. Herbal Nail Lacquer Contains plant-derived bioactive compounds with antifungal, antibacterial, anti-inflammatory, and antioxidant properties. Examples: Neem oil, Tea tree oil, Clove oil, Oregano oil, Castor oil, Garlic extract, Turmeric extract.

C. Based On Film-Forming Polymer

- Nitrocellulose-based nail lacquer
- Acrylic polymer-based nail lacquer
- Methacrylate polymer-based nail lacquer
- Cellulose derivative-based nail lacquer
- Polyvinyl acetate/polyvinyl alcohol-based nail lacquer

D. Based On Drug Release Pattern

- Immediate-release nail lacquer
- Sustained-release nail lacquer
- Controlled-release nail lacquer

E. Based On Composition

- Solvent-based nail lacquer
- Water-based nail lacquer
- Polymer-based nail lacquer
- Nano-formulated nail lacquer (nanoparticle, liposomal, or nanoemulsion-based systems)

Onychomycosis

Onychomycosis is a chronic fungal infection of the fingernails or toenails caused primarily by dermatophytes, and less commonly by non-dermatophyte molds and yeasts (Candida species). It is the most common nail disorder, accounting for approximately 50% of all nail diseases. The infection is characterized by discoloration, thickening, brittleness, deformation, and separation of the nail plate from the nail bed (onycholysis). If left untreated, onychomycosis may cause pain, discomfort, secondary bacterial infections, and impaired quality of life.

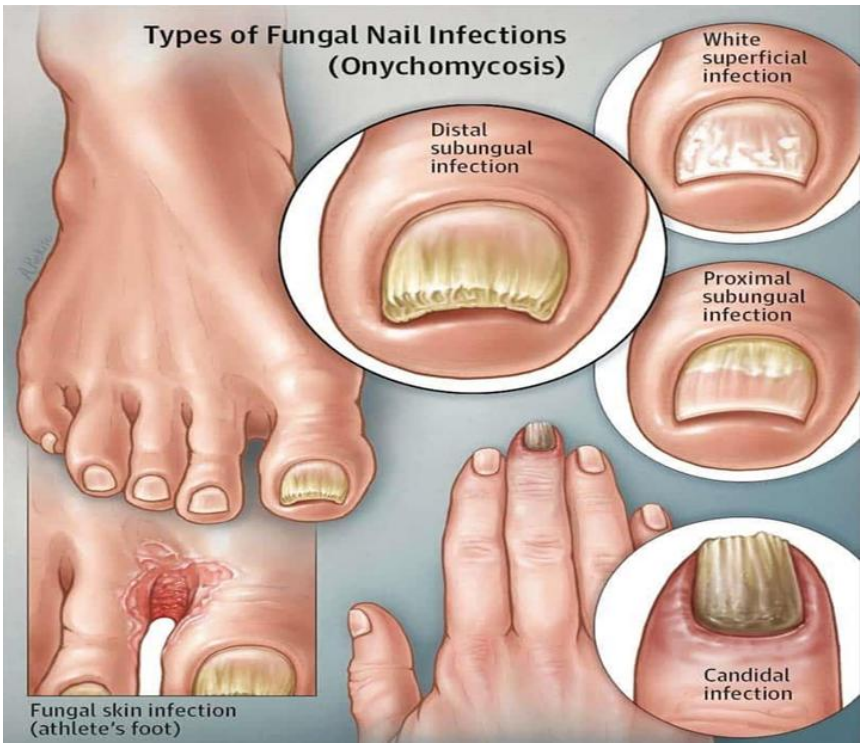


Fig. 4



FIG 5. Common types of toenail fungus

Pathogenesis Of Onychomycosis

The development of onychomycosis occurs through several sequential stages:

1. Fungal Exposure and Adhesion Fungal spores are acquired from contaminated surfaces such as floors, shoes, socks, nail instruments, or through direct contact with infected individuals. The fungi first adhere to the nail plate or the skin surrounding the nail (hyponychium or lateral nail folds).
2. Colonization Under favorable conditions such as warmth, moisture, trauma, diabetes, poor circulation, or immunosuppression, the fungi begin to multiply. Dermatophytes, particularly Trichophyton rubrum, are the most common causative organisms.
3. Keratin Degradation Fungi produce keratin-degrading enzymes (keratinases, proteases, lipases, and other hydrolytic enzymes). These enzymes digest the hard keratin of the nail plate, allowing the fungi to penetrate deeper into the nail.
4. Nail Plate Invasion The fungal hyphae spread through the keratinized layers of the nail plate and invade the nail bed and nail matrix. The infection progresses slowly because nails grow at a slow rate.
5. Tissue Damage Continuous fungal growth results in:

Thickening of the nail (subungual hyperkeratosis)
Yellow, white, or brown discoloration
Brittleness and crumbling of the nail
Separation of the nail plate from the nail bed (onycholysis)
Nail deformity and occasional pain

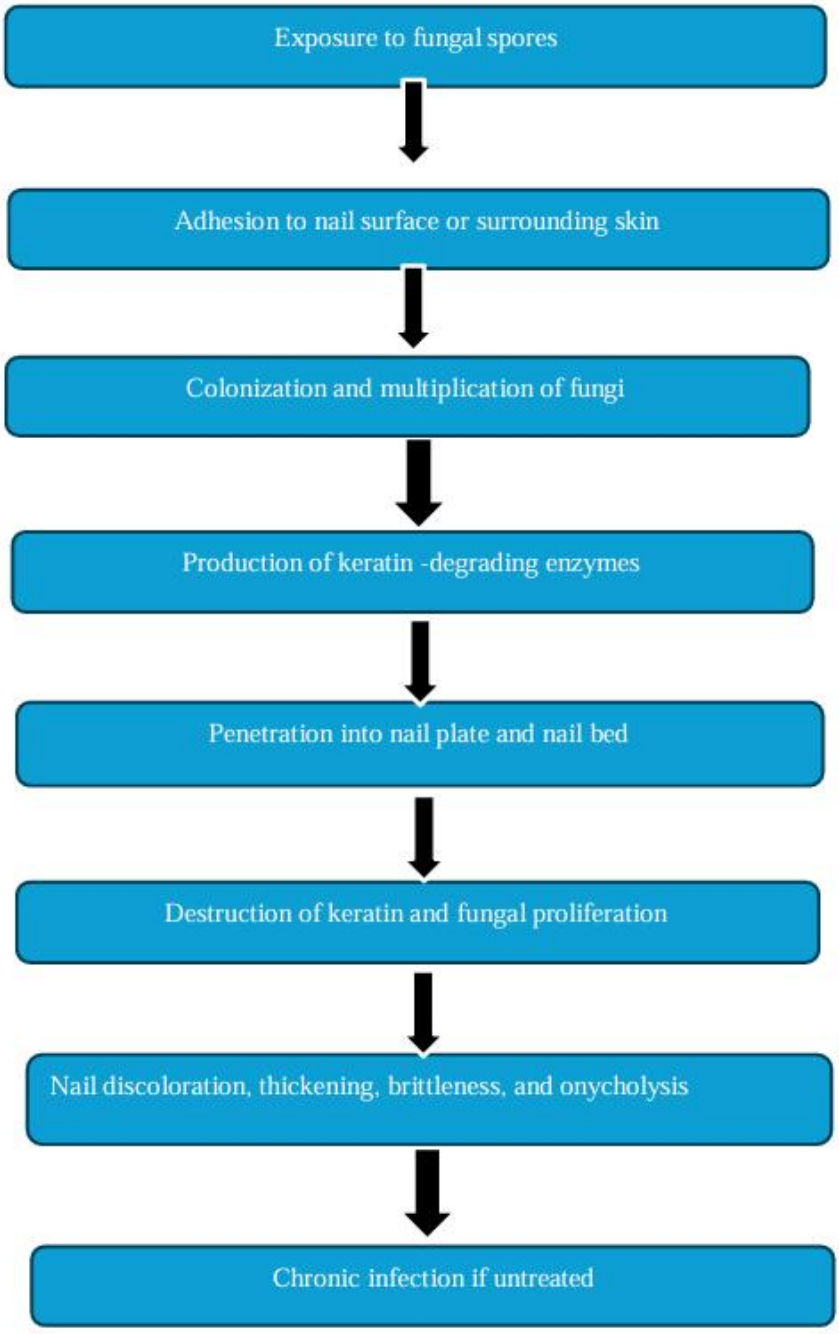
6. Host Immune Response The body initiates an inflammatory response to control fungal growth. However, the nail plate has limited blood supply and immune cell access, making complete eradication of the fungus difficult. Consequently, the infection often becomes chronic and recurrent if not treated adequately.

Common Causative Organisms

Dermatophytes: Trichophyton rubrum (most common), Trichophyton mentagrophytes, Epidermophyton floccosum.
Yeasts: Candida albicans, Candida parapsilosis
Non-dermatophyte Molds: Aspergillus spp., Fusarium spp., Scopulariopsis brevicaulis.



Fig. 6



Flowchart Of Pathogenesis

Literature Review

Murdan.S (2002), reviewed the challenges of delivering antifungal drugs through the nail plate and emphasized the importance of transungual drug delivery systems. The study, highlighted that nail lacquers improve drug retention on the nail surface and enhance penetration into the infected nail, making them more effective than conventional topical formulations.

Shivakumar HN et al. (2010), The researchers developed a medicated nail lacquer using a film-forming polymer and antifungal drug. The optimized formulation exhibited good film characteristics, rapid

drying, strong adhesion, and sustained drug release, demonstrating its potential for treating fungal nail infections.

Patel RP et al. (2011), Patel and co-workers formulated an antifungal nail lacquer and evaluated parameters such as drying time, viscosity, non-volatile content, water resistance, and drug release. The optimized formulation showed sustained drug release and effective nail adhesion, indicating its suitability for transungual drug delivery.

Ghannoum MA and Isham N (2014), The authors reviewed current therapies for onychomycosis and concluded that topical nail lacquers provide localized drug delivery with fewer systemic adverse effects. They suggested that combining effective antifungal agents with permeation enhancers can significantly improve treatment outcomes.

Puri et al. (2022) developed an antifungal nail lacquer containing econazole nitrate to improve transungual drug delivery for the treatment of onychomycosis. The formulation was optimized using a Quality by Design (QbD) approach. Eudragit RSPO (10% w/w) was selected as the film-forming polymer, and formulation variables such as the plasticizer and solvent system were optimized to produce a durable, adhesive nail lacquer. The researchers also incorporated a permeation-enhancing pretreatment to improve drug penetration through the nail plate. In vitro drug release and ex vivo nail permeation studies demonstrated sustained drug release and significantly enhanced penetration compared with the control formulation. The study concluded that the optimized nail lacquer is a promising topical drug delivery system for the effective treatment of onychomycosis.

Patil H.I., Awati A.S., and Mujumale D.N. (2023) formulated and evaluated a herbal nail lacquer containing neem oil for the treatment of onychomycosis. Neem oil was selected due to its well-known antifungal activity, while castor oil was incorporated for its anti-inflammatory properties. Ethyl cellulose was used as the film-forming polymer to provide sustained drug release, and ethyl acetate acted as the solvent and permeation enhancer. The nail lacquer was prepared by a simple mixing method and evaluated for viscosity, drying time, non-volatile content, and water resistance. The optimized formulation showed a viscosity of approximately 131 cP, a drying time of 3 minutes, and sustained drug release for up to 20 hours. The study concluded that the developed herbal nail lacquer demonstrated suitable physicochemical properties and has potential as an effective topical treatment for onychomycosis.

Objectives

1.To select suitable herbal antifungal agents (e.g., neem oil, tea tree oil, clove oil, or oregano oil) for the formulation

2. To formulate a stable herbal nail lacquer using appropriate film-forming polymers, plasticizers, and solvents.

3. To evaluate the physicochemical properties of the formulated nail lacquer, including: Drying time Viscosity Non-volatile content Water resistance Film adhesion Gloss and smoothness

4. To study the in vitro drug release and transungual permeation of the herbal formulation.

5. To assess the antifungal activity of the formulated nail lacquer against common fungal pathogens causing onychomycosis (e.g., Trichophyton rubrum and Candida albicans).

6. To evaluate the stability of the optimized formulation under suitable storage conditions.

7. To compare the performance of the herbal nail lacquer with a marketed antifungal nail lacquer.

Materials

MATERIALS

S.NO	INGREDIENTS	FUNCTOIN
1	Ethyl cellulose	Film - forming polymer
2	Castor oil	Plasticizer
3	Jojoba oil	Moisturizer
4	Neem oil	Antimicrobial
5	Tea tree oil	Antifungal
6	Natural mineral oil (mica pigment + carrot seed oil)	Colouring agent
7	Ethyl acetate	Main solvent
8	Ethanol	Co-solvent
9	HPMC (Hydroxypropyl methyl cellulose)	Film strength & Viscosity
10	Propylene glycol	Humectant
11	Glycerin	Moisturizer

Table1: Materials used for preparation of nail lacquer

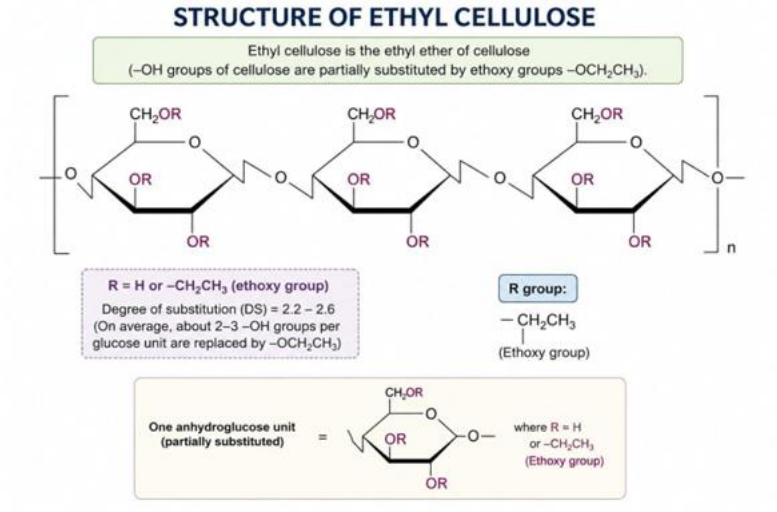
Ethyl Cellulose

Ethyl Cellulose (EC) is a cellulose derivative widely used in pharmaceutical formulations, especially in tablets, capsules, coatings, and nail lacquers.

Structure

- Chemical name: Ethyl Cellulose
- Chemical formula (repeating unit): Approximately $C_{12}H_{23}O_6(C_2H_5)_3$

It is produced by replacing some hydroxyl (-OH) groups of cellulose with ethyl ($-C_2H_5$) groups. It is water-insoluble but soluble in many organic solvents such as ethanol, acetone, and ethyl acetate.



Functions

- Film-forming polymer
- Binder
- Coating agent
- Sustained/controlled-release polymer
- Thickening and viscosity-enhancing agent
- Moisture barrier
- Stabilizer in formulations

Uses

- **Tablets:** Used as a binder and sustained-release coating.
- **Capsules:** Used for controlled drug release.
- **Nail lacquer:** Forms a tough, transparent film that adheres well to the nail and helps retain antifungal drugs for longer contact time.
- **Topical formulations:** Used in gels, creams, and transdermal systems. Microencapsulation: Used to encapsulate drugs and control their release.



Fig. 7

Ethyl cellulose role in Herbal Nail Lacquer for Onychomycosis;

- Primary film-forming polymer
- Provides strong adhesion to the nail plate
- Produces a smooth, transparent, protective film
- Improves drug retention on the nail
- Enables prolonged release of the herbal antifungal agent, improving treatment

Castor Oil

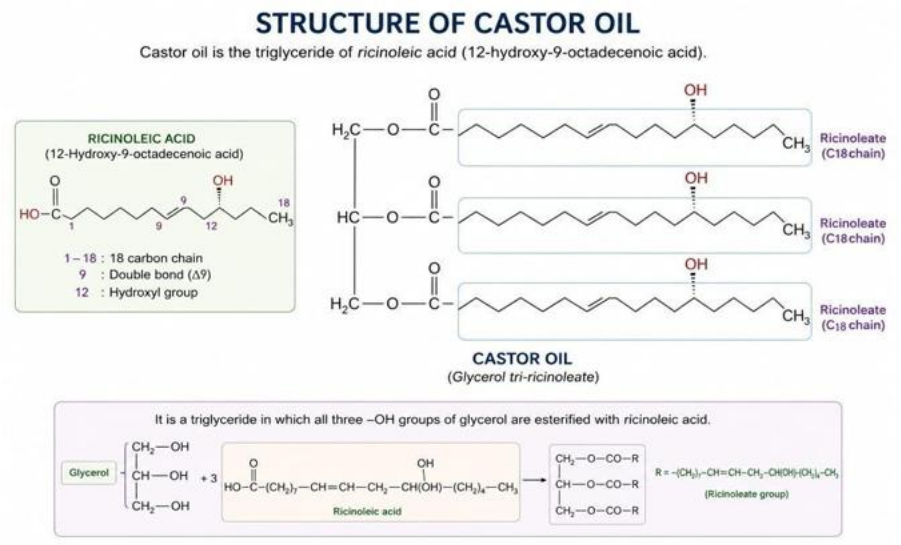
- Botanical source: Ricinus communis
- Family: Euphorbiaceae

Structure / Composition

- Major constituent: Ricinoleic acid (about 85–90%)

Other fatty acids:

- Oleic acid
- Linoleic acid
- Stearic acid
- Palmitic acid



Functions

- Plasticizer
- Emollient (softens and moisturizes)
- Penetration enhancer
- Lubricant
- Solvent/vehicle for some drugs
- Improves flexibility of films

Uses

- Used in pharmaceutical formulations as a vehicle and lubricant.
- Used in cosmetic products such as lipsticks, creams, hair oils, and nail products.
- Used in topical formulations to improve skin and nail hydration.
- Used as a mild laxative in oral pharmaceutical preparations (medicinal use).

- Used in herbal nail lacquers to improve film flexibility and reduce cracking.



Fig. 8

Role in Herbal Nail Lacquer for Onychomycosis

- Acts as a plasticizer, making the film flexible.
- Prevents the lacquer film from becoming brittle.
- Enhances adhesion of the film to the nail.
- Helps improve spread ability and application.
- May slightly enhance penetration of the herbal antifungal agent into the nail.

Jojoba Oil

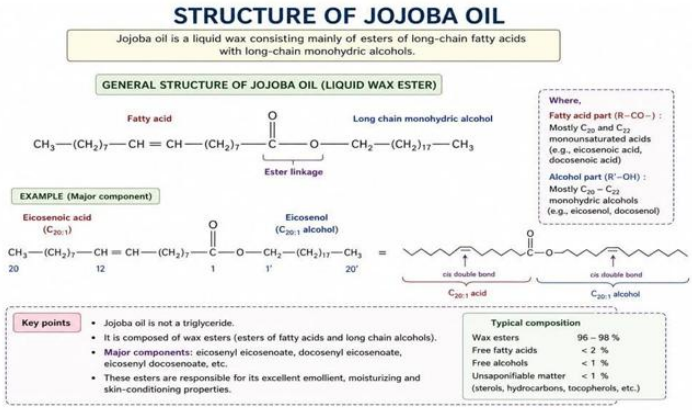
- Botanical source: Simmondsia chinensis
- Family: Simmondsiaceae

Structure / Composition

- Jojoba oil is not a true oil; it is a liquid wax ester composed mainly of:

Long-chain wax esters (≈97–98%)

- Eicosenoic acid
- Erucic acid
- Oleic acid (small amount)
- Natural vitamin E (tocopherols)



Functions

- Emollient
- Moisturizer
- Plasticizer
- Penetration enhancer
- Film-conditioning agent
- Stabilizer against oxidation

Uses

- Used in creams, lotions, shampoos, and conditioners.
- Used in lip balms and cosmetics.
- Used in topical pharmaceutical formulations.
- Used in nail care products and herbal nail lacquers.

Helps improve skin and nail hydration



Fig. 9

Role in Herbal Nail Lacquer for Onychomycosis

- In a herbal nail lacquer, jojoba oil:
- Acts as a plasticizer to improve film flexibility.
- Moisturizes the nail and surrounding skin.
- Improves spread ability and smooth application.
- Helps reduce cracking and peeling of the lacquer film.
- May enhance penetration of herbal antifungal agents into the nail.

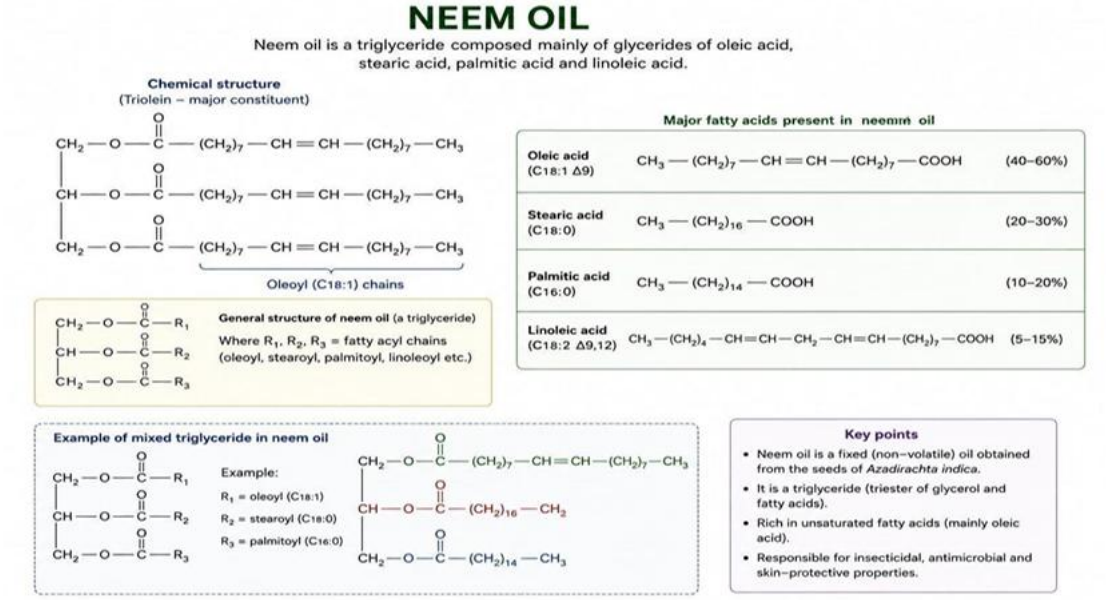
Neem Oil

- Botanical name: Azadirachta indica
- Family: Meliaceae Structure / Major Constituents

Neem oil is a vegetable oil extracted from neem seeds.

Its major constituents include:

- Azadirachtin
- Nimbin
- Nimbidin
- Salannin
- Gedunin
- Fatty acids (oleic, stearic, palmitic, and linoleic acids)



Functions

- Antifungal agent
- Antibacterial agent
- Anti-inflammatory agent
- Antioxidant

Uses

- Used in creams, ointments, lotions, and soaps.
- Used in pharmaceutical and cosmetic formulations.
- Used in herbal preparations for treating fungal skin and nail infections.
- Promotes healthy skin and nails.



Fig. 10

Role in Herbal Nail Lacquer for Onychomycosis

- Acts as the primary herbal antifungal agent.
- Inhibits the growth of fungi responsible for onychomycosis.
- Reduces inflammation around the infected nail.
- Helps protect the nail from secondary microbial infections.
- Supports healthy nail growth.

Tea Tree Oil

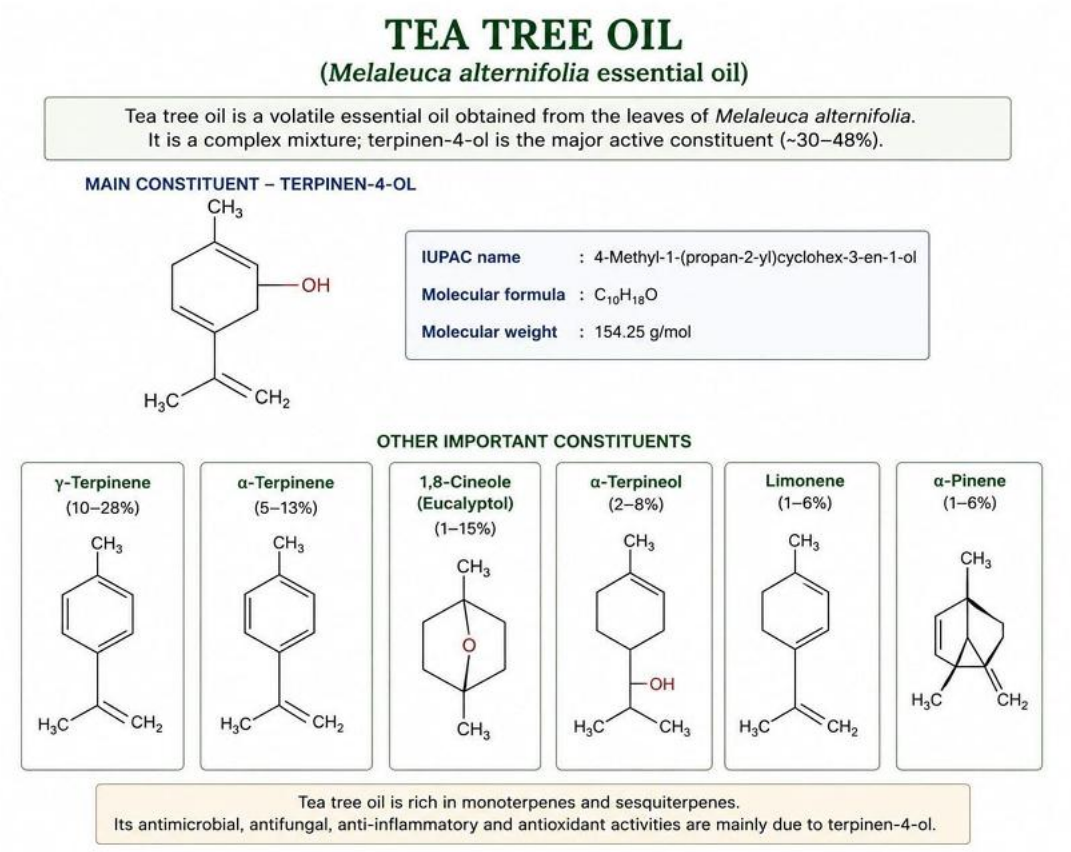
- Botanical name: Melaleuca alternifolia
- Family: Myrtaceae

Structure / Major Constituents

Tea tree oil is an essential oil obtained from the leaves of the tea tree. Its major constituents are:

Terpinen-4-ol (main active component)

- γ-Terpinene
- α-Terpinene
- 1,8-Cineole
- α-Terpineol
- p-Cymene



Functions

- Antifungal agent
- Antibacterial agent
- Anti-inflammatory agent
- Antiseptic
- Antioxidant

Uses

- Used in creams, ointments, gels, and lotions.
- Used in shampoos, soaps, and cosmetic products.
- Used in topical pharmaceutical formulations for fungal and bacterial infections.
- Used in nail care products for fungal nail infections (onychomycosis).



Fig. 11

Role in Herbal Nail Lacquer for Onychomycosis

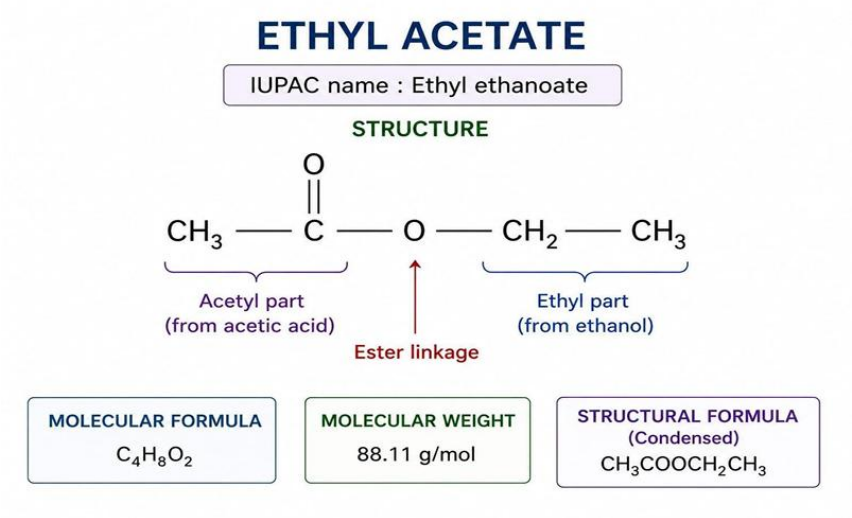
- Acts as the primary herbal antifungal agent.
- Inhibits the growth of fungi such as Trichophyton rubrum and Candida albicans.
- Helps reduce inflammation and discomfort around the infected nail.
- Enhances the overall antifungal effectiveness of the formulation.

Ethyl Acetate

Structure

- Chemical name: Ethyl acetate
- Molecular formula: $C_4H_8O_2$
- Chemical structure: $CH_3COOCH_2CH_3$

It is a colourless, volatile liquid with a characteristic fruity odour.



Functions

- Solvent
- Volatile carrier
- Film-forming solvent
- Viscosity modifier
- Fast-drying agent

Uses

- Used as a solvent in pharmaceutical and cosmetic formulations.
- Used in nail polish and nail lacquer formulations.
- Used in inks, paints, adhesives, and coatings.
- Used for extraction and purification processes in laboratories.



Fig. 12

Role in Herbal Nail Lacquer for Onychomycosis

- Acts as the primary solvent for polymers such as ethyl cellulose.
- Dissolves herbal extracts and other formulation ingredients.
- Evaporates rapidly after application, leaving a smooth, uniform film on the nail.
- Contributes to quick drying and improved film formation.

ETHANOL

Structure

Chemical name: Ethanol (Ethyl alcohol)

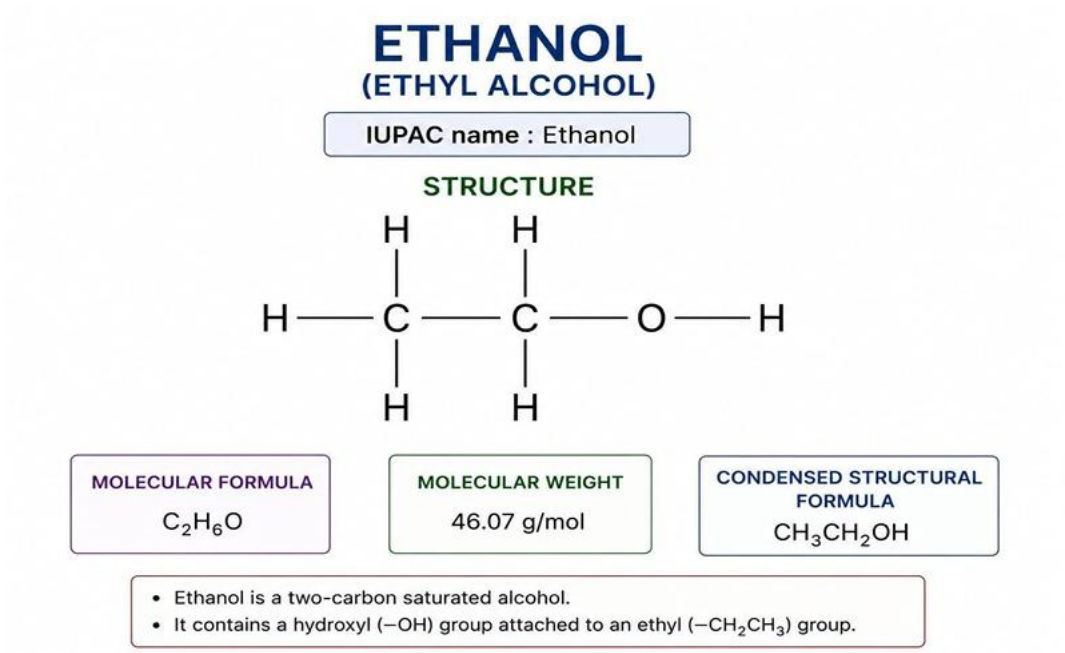
Molecular formula: C_2H_6O

Chemical structure: CH_3CH_2OH

It is a clear, colourless, volatile, and flammable liquid.

Functions

- Solvent
- Co-solvent
- Antimicrobial agent (at appropriate concentrations)
- Penetration enhancer
- Fast-drying agent



Uses

- Used as a solvent in pharmaceutical, cosmetic, and herbal formulations.
- Used in tinctures and herbal extracts.
- Used in hand sanitizers and disinfectants.
- Used in perfumes, nail products, and topical preparations.
- Used for extraction of plant constituents.



Fig. 13

Role in Herbal Nail Lacquer for Onychomycosis

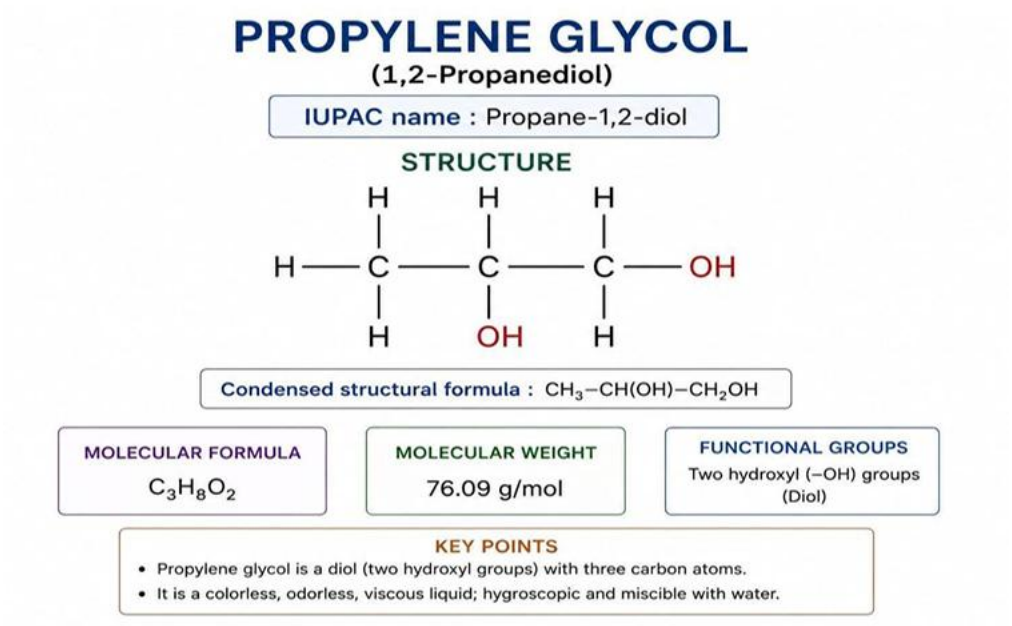
- Acts as a co-solvent with ethyl acetate to dissolve polymers (e.g., ethyl cellulose) and herbal ingredients.
- Enhances the penetration of antifungal agents into the nail plate.
- Evaporates quickly, promoting rapid drying of the lacquer.
- Helps produce a smooth, uniform film on the nail surface.

Propylene Glycol

Structure

- Chemical name: Propylene glycol
- IUPAC name: Propane-1,2-diol
- Molecular formula: $C_3H_8O_2$
- Chemical structure: $CH_3–CHOH–CH_2OH$

It is a clear, colourless, odourless, hygroscopic liquid.



Functions

- Solvent
- Co-solvent
- Humectant (retains moisture)
- Penetration enhancer
- Plasticizer
- Viscosity modifier

Uses

- Used in pharmaceutical formulations as a solvent and vehicle.
- Used in creams, gels, ointments, and lotions.
- Used in cosmetics and personal care products.
- Used in oral, topical, and injectable formulations.

- Used in nail lacquers to improve flexibility and drug penetration.



Fig. 14

Role in Herbal Nail Lacquer for Onychomycosis

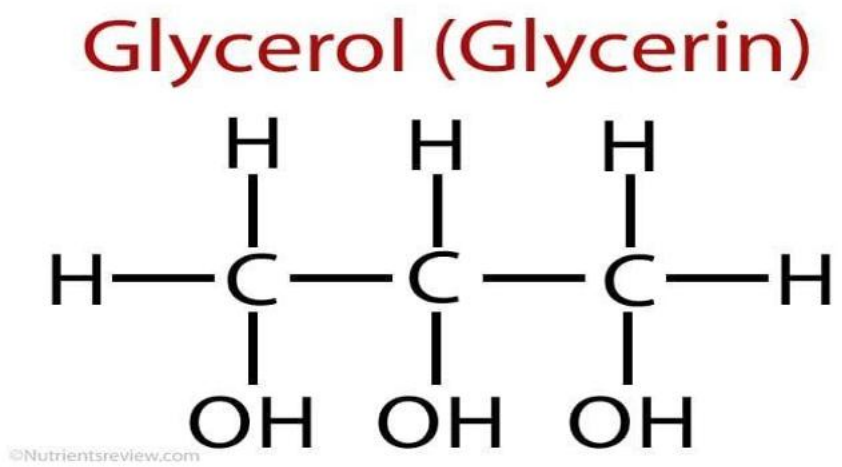
- Acts as a co-solvent for herbal extracts and other ingredients.
- Enhances the penetration of antifungal agents through the nail plate.
- Functions as a humectant to prevent excessive drying.
- Improves film flexibility and reduces cracking.
- Helps achieve uniform application of the lacquer.

Glycerin(Glycerol)

Structure

- Chemical name: Glycerin (Glycerol)
- IUPAC name: Propane-1,2,3-triol
- Molecular formula: $C_3H_8O_3$
- Chemical structure: $HOCH_2–CHOH–CH_2OH$

It is a clear, colourless, odourless, sweet, and hygroscopic liquid.



Functions

- Humectant (retains moisture)
- Plasticizer
- Solvent
- Emollient
- Moisturizer
- Viscosity modifier

Uses

- Used in creams, lotions, gels, and ointments.
- Used in oral syrups and pharmaceutical formulations as a solvent and sweetening agent.
- Used in cosmetics and personal care products.
- Used in topical formulations to prevent dryness.
- Used in nail care products to improve nail hydration.



Fig. 15

Role in Herbal Nail Lacquer for Onychomycosis

- Acts as a humectant to keep the nail hydrated.

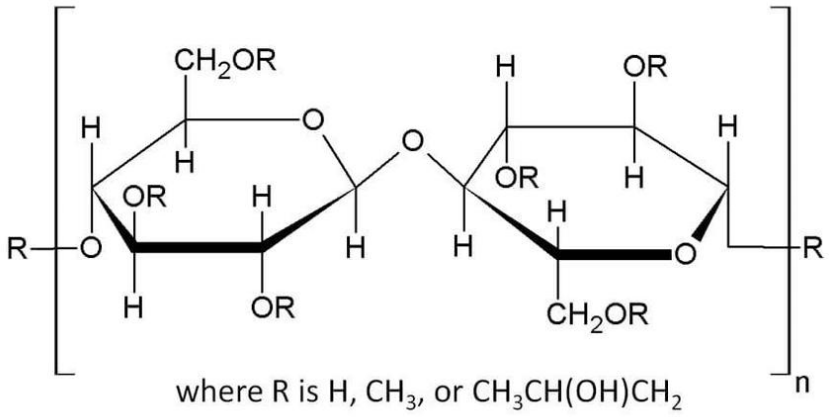
- Functions as a plasticizer, improving film flexibility.
- Prevents the lacquer film from becoming brittle and cracking.
- Enhances smooth application and spread ability.
- Helps maintain nail health during antifungal treatment

Hydroxy Propyl Methyl Cellulose

Structure

- Chemical name: Hydroxypropyl Methylcellulose (HPMC)
- Also known as: Hypromellose
- Repeating unit: Cellulose backbone with methoxy ($-OCH_3$) and hydroxypropyl ($-OCH_2CHOHCH_3$) substituent groups.

It is a semi-synthetic, water-soluble cellulose derivative.



Functions

- Film-forming agent
- Binder
- Thickening agent
- Viscosity enhancer
- Controlled-release polymer
- Stabilizer

Uses

- Used as a binder in tablets.
- Used as a film-coating agent for tablets and capsules.
- Used in ophthalmic (eye) preparations as a lubricant.
- Used in gels, creams, and topical formulations.
- Used in sustained-release pharmaceutical formulations.



Fig. 16

Role in Herbal Nail Lacquer for Onychomycosis

In a herbal nail lacquer, HPMC:

- Acts as a film-forming polymer.
- Forms a smooth, transparent coating on the nail surface.
- Improves adhesion of the lacquer to the nail plate.
- Controls the release of herbal antifungal agents.
- Enhances the stability and uniformity of the formulation.

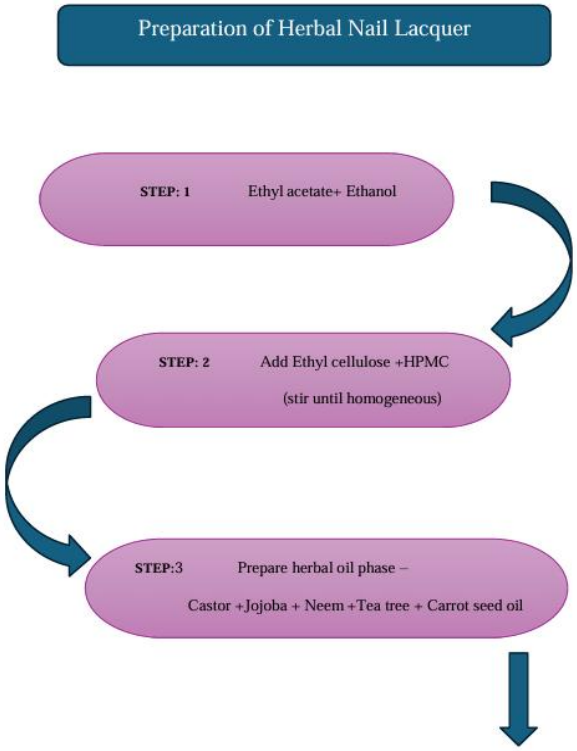
Methods Of Preparation:

Preparation of Herbal Nail Lacquer for the Treatment of Onychomycosis

The herbal nail lacquer was prepared by the solvent evaporation method using a polymeric film-forming system. The formulation was designed to provide good adhesion, uniform film formation, and effective delivery of herbal antifungal agents.

1. Preparation of polymer solution: Ethyl acetate and ethanol were mixed in a clean, dry beaker in the required ratio under continuous magnetic stirring. Ethyl cellulose was gradually added to the solvent mixture and stirred until completely dissolved. HPMC was then slowly incorporated and the solution was stirred continuously until a clear and homogeneous polymer solution was obtained.
2. Preparation of herbal oil phase: Castor oil, jojoba oil, neem oil, tea tree oil, and carrot seed oil were accurately measured and mixed together in a separate beaker. The mixture was stirred gently to obtain a uniform herbal oil phase.
3. Addition of plasticizers: Propylene glycol and glycerin were added to the herbal oil mixture and stirred for 10–15 minutes to improve flexibility and moisture retention of the final film.

4. Formulation of nail lacquer: The herbal oil phase was added slowly into the polymer solution under continuous stirring. The mixture was stirred for 30–45 minutes until a smooth, uniform, and bubble-free formulation was obtained.
5. Addition of pigment: A small quantity of cosmetic-grade mica pigment was dispersed into the formulation and mixed thoroughly to ensure uniform colour distribution.
6. Degassing and filtration: The prepared formulation was allowed to stand for 15–20 minutes to remove entrapped air bubbles. It was then filtered through a fine muslin cloth or 0.45 µm filter to obtain a clear and homogeneous nail lacquer.
7. Filling and storage: The final herbal nail lacquer was transferred into sterile amber glass nail lacquer bottles fitted with an applicator brush. The bottles were tightly closed and stored at room temperature (25 ± 2°C), protected from direct sunlight and moisture until further evaluation.



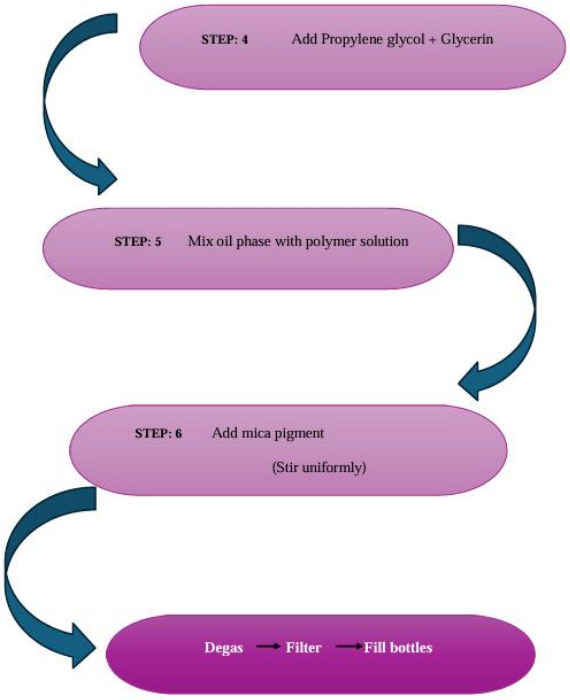


Table:2 Preparation of nail lacquer -different batches

INGREDIENTS	F1	F2	F3	F4	F5	F6
Ethyl cellulose	0.90 g	1.05g	**1.20g**	1.35g	1.50g	1.65g
Castor oil	0.30ml	0.30ml	**0.30ml**	0.30ml	0.30ml	0.30ml
Jojoba oil	0.225ml	0.225ml	**0.225ml**	0.225ml	0.225ml	0.225ml
Neem oil	0.075ml	0.075ml	**0.075ml**	0.075ml	0.075ml	0.075ml
Tea tree oil	0.075ml	0.075ml	**0.075ml**	0.075ml	0.075ml	0.075ml
HPMC	0.15g	0.225g	**0.30g**	0.30g	0.30g	0.375g
Propylene glycol	0.225ml	0.225ml	**0.225ml**	0.225ml	0.225ml	0.225ml
Glycerin	0.075ml	0.075ml	**0.075ml**	0.075ml	0.075ml	0.075ml
Ethyl acetate	q.s	q. s	**q. s**	q. s	q. s	q. s
Ethanol	q. s	q. s	**q. s**	q. s	q. s	q. s
Mica\Carrot seed oil	As required	As required	**As required**	As required	As required	As required
FINAL VOLUME	**15ml**	**15ml**	**15ml**	**15ml**	**15ml**	**15ml**

Evaluation

Formulated nail lacquers were subjected to preliminary evaluation tests.

a) Drying Time

Drying time for formulations F1 to F4 was found between 30 seconds to 80 seconds. It was found that as the polymer concentration increases from 0.5% w/v to 2% w/v the drying time increases respectively. The time required for the solvent to evaporate from the more viscous solution is more than the less viscous solution. Formulation F5 showed optimum drying time of about 100 sec. Formulation F6 showed maximum drying time as it contained higher amount of polymer.

Table3: Drying time of various batches

BATCH	ETHYL CELLULOSE	DRYING TIME (Sec)
F1	0.90g	30 sec
F2	1.05g	40 sec
F3	1.20g	50 sec
F4	1.35g	60 sec
F5	1.50g	70 sec
F6	1.65g	90 sec

b) Smoothness to flow and gloss

Optimized formulation F3 when poured onto the glass plate was found to have satisfactory flow property and result in a uniform smooth film, as compared to other formulation batches.

c) Non-Volatile Content of Nail Lacquer

The increase in polymer concentration from 0.5% to 3% causes increase in non volatile content of nail lacquer. Non- Volatile Content depends on polymer content. Thus, higher the polymer concentration higher is the non-volatile content of nail Lacquer.

d) Viscosity

The viscosity of the sample varied from 114 to 131 centipoise (cp). This viscosity range provided good adherence and flow property. The viscosity of various formulation batches.

Table4: Viscosity of formulated batches

FORMULATION BATCH	VISCOSITY (cP)
F1	115
F2	113
F3	118
F4	124
F5	128
F6	133

e) Water Resistance Test

As shown increase in polymer concentration increases the water resistance. Formulation F1, F2, F5 and F6 shows lower water resistance than F3 and F4.

Table5: Water resistance test formulated batches

FORMULATION BATCH	W a 1(gm)	W b 2(gm)	DIFFERENCE IN WEIGHT (gm)
F1	5.00	5.28	0.28
F2	5.00	5.35	0.35
F3	5.00	5.38	0.39
F4	5.00	5.41	0.38
F5	5.00	5.28	0.35
F6	5.00	5.44	0.37

f) Drug Content Estimation

Percentage drug content for all the formulation batches were found to be satisfactory and in between 80.0% 96.0% which is reported in Table 6. Highest % of drug content was found to be 96% (F5) and the lowest 80% of drug content (F1). If the drug content is more than 90% the formulation shows high amount of drug present in it. This, ensure better therapeutic response.

Table:6 Drug content estimation of formulated batches

FORMULATION BATCHES	DRUG CONTENT (%)
F1	80.0±0.02
F2	83.46±0.17
F3	85.0±0.22
F4	86.40±0.20
F5	96.0±0.03
F6	96.8±0.14

In vitro diffusion study

Franz diffusion cell was used to conduct diffusion experiments with a artificial membrane (cellophane). On the membrane's surface, an optimised nail lacquer formulation (F3) was evenly applied. Similar

study was performed using castor oil and neem oil only. The diffusion study was continued up to 20 hours, as shown in Fig.17. Nail lacquer formulation (F3) showed the highest release of 94.48%. It was found that due to presence of permeation enhancer (salicylic acid), the release of drug increases. Moreover, ethyl cellulose sustains the release of castor oil and neem oil up to 20 hours. The expected mechanism of permeation of nail lacquer is shown in Fig.18.

Time	F3 cumulative % release	Castor oil control	Neem oil control
0 h	0.00± 0.00	0.00 ± 0.00	0.00 ± 0.00
1 h	12.10 ± 0.34	7.85 ± 0.22	6.70± 0.19
2 h	20.45 ± 0.41	13.90 ± 0.28	12.15 ± 0.27
4 h	31.60 ± 0.52	20.85 ± 0.33	18.20± 0.31
8 h	52.35 ± 0.74	34.60 ± 0.49	30.10 ± 0.46
12 h	69.10 ± 0.88	46.75 ± 0.60	41.30 ± 0.57
16 h	83.20 ± 0.95	58.80± 0.69	52.10 ± 0.66
20 h	**94.48 ± 0.96**	67.90 ± 0.73	60.15 ± 0.72

Figure 7: In-vitro diffusion/release

Stability Study

The submitted study reports storage of the medicated nail lacquer at 37 °C for one month and states that colour non-volatile content, viscosity, drying time and smoothness did not change significantly. The final thesis should present the actual observations at each time point rather than only the conclusion.

Parameter	Initial	Week 1	Week 2	Week 3	Week 4
Appearance	Clear, homogeneous	Clear, homogeneous	Clear, homogeneous	Clear, homogeneous	Clear, homogeneous
Colour	No change	No change	No change	No change	No change
Viscosity(cP)	118	119	120	122	124
Drying time(sec)	50	51	52	53	54
Non-volatile content (%)	32.5%	32.4%	32.4%	32.3%	32.2%
Smoothness/film	Smooth, Uniform	Smooth, Uniform	Smooth, Uniform	Smooth, Uniform	Smooth, Uniform

Table 8: Stability study of optimized formulation

Statistical presentation

For measurements performed in replicate, report mean ± SD and state n. Where groups are compared, state the statistical test and significance level used. Do not add p-values without the underlying raw observations.

Parameter	Initial	Week 1	Week 2	Week 3	Week 4
Viscosity(cP)	118 ± 2	119 ± 2	120 ± 2	122 ± 2	124 ± 3
Drying time(sec)	50 ± 2	51 ± 2	52 ± 2	53 ± 2	54 ± 2
Non-volatile content (%)	32.5± 0.3	32.4 ± 0.3	32.4 ± 0.2	32.3± 0.3	32.2 ± 0.2

F3 showed only a slight increase in viscosity and drying time during the 4-week stability study, while appearance, colour and film smoothness remained unchanged.

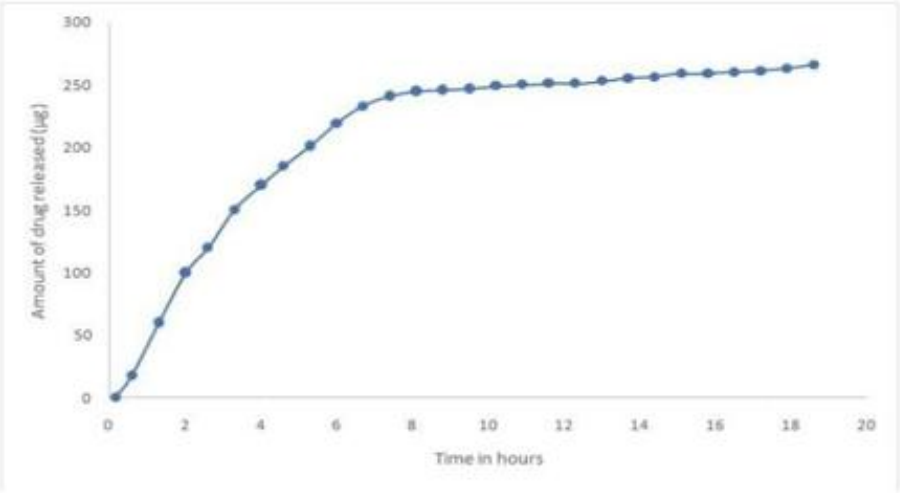


Figure 17: In – Vitro diffusion studies

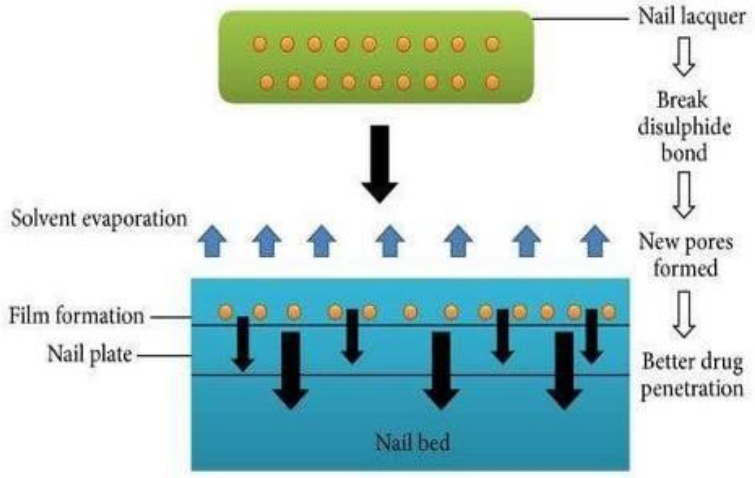


Figure 18: Mechanism of permeation of nail lacquer

Result & Disscusion

The formulated nail lacquer batches F1-F6 were evaluated for selected physicochemical and performance characteristics. The progressive increase in ethyl cellulose was associated with an increase

in drying time and viscosity across the reported batches. The numerical drying times increased from 30 seconds for F1 to 90 seconds for F6, while viscosity ranged from 113 to 133 cP.

F3 was reported to provide satisfactory flow, smoothness and gloss and was identified in the submitted work as the optimized formulation. However, the final selection should be based on a predefined overall optimization criterion incorporating all measured parameters. The drying time narrative should be corrected so that it agrees with the numerical table and the final optimized batch.

The reported content/assay values increased from 80.0% for F1 to 96.8% for F6. These findings should be discussed in terms of the analytical method and content uniformity rather than assuming that a higher value directly produces a greater therapeutic response.

The in-vitro diffusion study reported a cumulative release of 94.48% for F3 at 20 hours. The final thesis should identify the measured marker/analyte and provide the complete release profile and calculation. Any statement concerning salicylic acid must be reconciled with the actual formulation composition.

The submitted stability study reported no significant change during one month at 37 °C. The final report should show the individual observations and measured values at each time point and should describe the storage condition accurately.

Future Scope

1. Optimization: Further optimization can be performed using a systematic design approach to identify the most suitable polymer concentration and excipient ratios.
2. Analytical standardization: A suitable marker-based analytical method should be developed and validated for quantitative estimation of the selected herbal active component(s).
3. Transungual permeation: Ex-vivo nail permeation studies using human or suitable animal nail models may be undertaken where ethically and scientifically appropriate.
4. Antifungal spectrum: Activity can be evaluated against clinically relevant dermatophytes and yeasts using validated microbiological methods.
5. Long-term stability: Accelerated and long-term stability studies should be performed according to an appropriate stability protocol.
6. Safety: Local irritation, sensitization and other relevant safety studies should be considered before clinical use.
7. Comparative performance: The optimized formulation may be compared with an appropriate marketed medicated nail lacquer using predefined endpoints.
8. Clinical evaluation: Properly designed clinical studies are required to establish effectiveness, tolerability, adherence and patient acceptability.

Conclusion

A herbal nail lacquer was formulated using the selected herbal oils and polymeric film-forming system described in the study. Six formulation batches (F1-F6) were prepared by varying the polymer composition and were subjected to physicochemical evaluation.

Based on the reported observations, the formulations demonstrated acceptable physical characteristics, with differences among batches in drying time, viscosity and water-resistance behaviour. F3 was identified in the submitted work as the optimized formulation on the basis of satisfactory flow,

smoothness and gloss; however, this designation should be retained only after confirming the complete optimization dataset.

The submitted in-vitro diffusion study reported 94.48% cumulative release for F3 at 20 hours. The herbal nail lacquer also showed reported antifungal activity. These findings indicate potential for further investigation as a topical nail-delivery system for onychomycosis.

The study is preliminary and does not by itself establish clinical efficacy or safety. Further validated analytical studies, nail-penetration/transungual studies, extended stability studies, safety assessment, in-vivo studies and appropriately designed clinical investigations are required before therapeutic effectiveness can be established.

Recommended final sentence: "The optimized herbal nail lacquer demonstrated promising preliminary physicochemical and in-vitro performance and warrants further investigation as a potential topical approach for the management of onychomycosis."

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