Development and Evaluation of Nanosponge Contaning Terbinafine Hydrochloride

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ABSTRACT

Healthcare professionals continue to struggle with fungal infections. In this work, the Emulsion Solvent Diffusion Method is used to develop, formulate and assess a nanosponge system loaded with Terbinafine Hydrochloride (TH). The goal of the current study was to increase Terbinafine Hydrochloride's ability to treat fungal infections by improving medication delivery.

Ethyl Cellulose, Polyvinyl Alcohol and Hydroxy Propyl Methyl Cellulose (HPMC) were used as polymers to develop the nanosponges, which were then created using the Emulsion Solvent Diffusion Method. 6 batches of nanosponges were developed, and their compatibility features were evaluated using a variety of characterization techniques, such as Scanning Electron Microscopy, Fourier-Transform Infrared Spectroscopy and particle size analysis.

There are bright potential for enhancing antifungal therapy with the creation of Terbinafine Hydrochloride-loaded nanosponges employing the Emulsion Solvent Diffusion approach. The nanosponges increased antifungal efficacy and prolonged drug release point to the possibility of using them as an innovative medication delivery mechanism to treat fungus infections.

(**Key words**- Nanosponges, antifungal, Emulsion Solvent Diffusion Method, Terbinafine Hydrochloride)

INTRODUCTION

FUNGAL INFECTION:

A fungal infection, also known as a mycosis, is an infection caused by different types of fungies. Fungi are microorganisms that can be found in the environment, such as in soil, plants, and even on human skin. While most fungi are harmless or even beneficial, but some can cause infections when they enter into the body and multiply.[1,2]

Annually about 40 millions of cases are observed in all over the world of fungal infection. About approximately 600 species of fungus may causes infection. Fungal infections can affect different parts of the body, including the skin, nails, hair, mouth, throat and genitals.[3]

ANTIFUNGAL DRUGS:

To treat fungal infections there are various drugs are available in market, which are classified according to following classes:

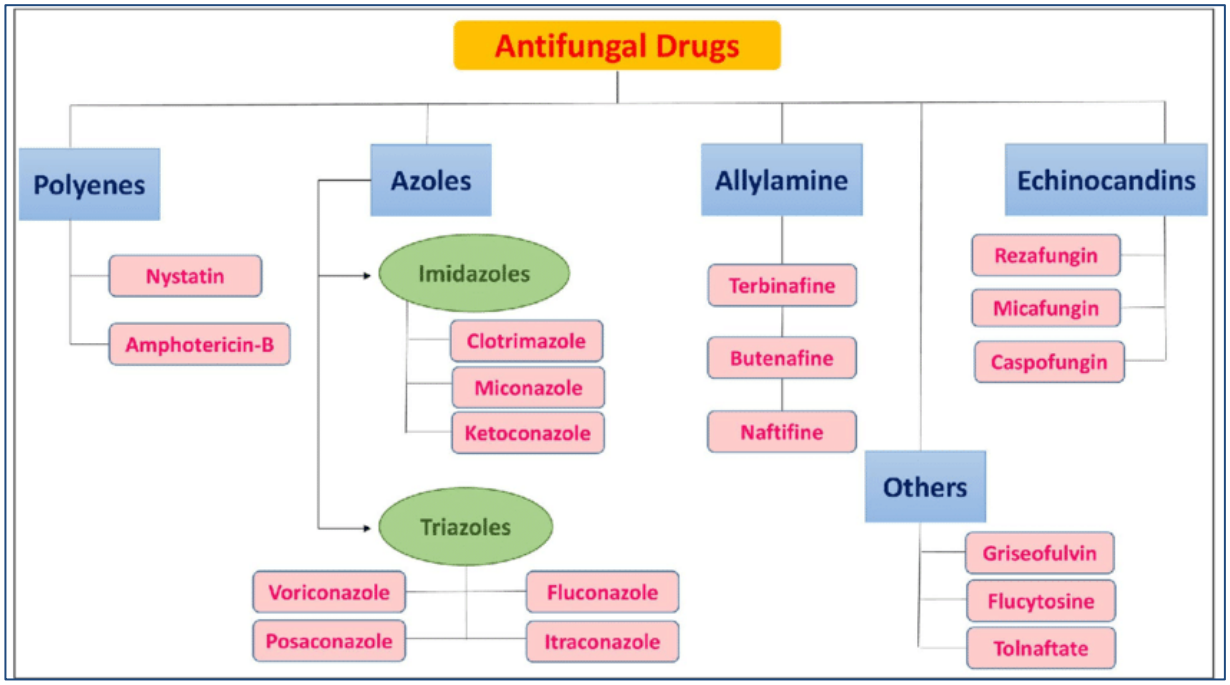


Fig.1: Classification of Atifungal drugs

ONYCHOMYCOSIS:

Onychomycosis is a medical term that refers to a fungal infection of the nails. It specifically affects the fingernails and toenails. The condition is caused by various types of fungi, including dermatophytes, yeasts, and molds. Onychomycosis typically starts at the edge or tip of the nail and gradually spreads deeper into the nail bed and nail plate.

Common symptoms of onychomycosis include:

- Discoloration: The infected nail may become yellow, brown, green, or white.
- Thickening: The affected nail can become thicker and harder than usual.
- Brittleness: The infected nail may become brittle and prone to breakage.
- Distortion: The shape of the nail can become distorted, with irregularities and an uneven surface.
- Detachment: The nail may separate from the nail bed, causing pain or discomfort.[4]

Onychomycosis can be caused by several factors, including poor hygiene, wearing tight or non-breathable footwear, walking barefoot in public areas like swimming pools or locker rooms, having a weakened immune system or having a history of nail injuries or damage. It is more common in toenails than fingernails.

Fig 2: Toenail Onychomychosis

Fig.3: Fingernail Onychomychosis

Diagnosis of onychomycosis is typically made through a physical examination of the affected nails and may involve laboratory tests, such as nail clippings or scrapings, which are examined under a microscope or cultured to identify the specific type of fungus.

Treatment options for onychomycosis include topical anti fungal medications, oral anti fungal drugs, and in some cases, surgical removal of the infected nail. The choice of treatment depends on the severity and extent of the infection.

Prevention of onychomycosis involves practicing good nail hygiene, keeping nails clean and dry, wearing breathable footwear, avoiding sharing personal items like nail clippers or files, and using anti fungal powders or sprays in shoes when necessary.[5]

NOVEL DRUG DELIVERY SYSTEM:

A novel drug delivery system (NDDS) is an innovative approach developed to enhance the delivery and targeting of pharmaceutical drugs to specific sites within the body. It aims to improve therapeutic efficacy, minimize side effects and optimize treatment outcomes. NDDS involves the use of advanced technologies, materials and formulations to overcome the limitations of conventional drug delivery methods.

These innovative delivery systems offer several advantages. They can enhance the stability and solubility of drugs, improve drug bio-availability, and prolong drug release to maintain therapeutic levels over an extended period. NDDS also allows for site-specific targeting, which minimizes off-target effects and reduces the required drug dosage. [6]

Examples of various novel drug delivery systems :

- Nanosponges
- Liposomes
- Nanoparticles
- Microneedles
- Implants
- Micelles
- Nanocrystals
- Trans-dermal patches
- Emulsions
- Solid-liquid Nanoparticles[6]

NANOSPONGES:

Nanosponges are the nonporous structures composed of bio-compatible materials, such as polymers, that can absorb and release drugs or other substances. Nanosponges are mesh-like structured nano-sized particles having size 200-400nm. Nanosponges are used in diverse areas, including cancer therapy,

antimicrobial treatment, toxin removal and diagnostic imaging. These nanosponges can formulated in the forms of creams, gels, tablets, ointments, etc. [7,8,9]

NEED OF PRESENT STUDY:

The need for studying Terbinafine Hydrochloride nanosponges in the treatment of Onychomycosis arises from the limitations of current treatment options, including their limited efficacy, long treatment durations, high recurrence rates and systemic side effects. Innovative approaches like nanosponges hold promise in addressing these challenges and improving therapeutic outcomes.

OBJECTIVES:

- Assess the efficacy and impact of Terbinafine Hydrochloride nanosponges on Onychomycosis patients.
- Determine the optimal dosage and frequency of administration for Terbinafine Hydrochloride nanosponges in Onychomycosis treatment.
- Compare the therapeutic outcomes of Terbinafine Hydrochloride nanosponges with conventional treatment options for Onychomycosis.
- Investigate the long-term efficacy and durability of Terbinafine Hydrochloride nanosponges in preventing relapse of Onychomycosis.
- Explore the potential of Terbinafine Hydrochloride nanosponges to improve patient adherence and treatment compliance.
- Improve therapeutic outcomes, minimize side effects, enhance patient compliance, and explore innovative drug delivery strategies.

SCOPE:

- The study of Terbinafine Hydrochloride nanosponges focuses on their effectiveness in resisting Onychomycosis.
- Terbinafine Hydrochloride nanosponges have the potential to enhance drug delivery to the affected area.
- The scope of studying these nanosponges involves assessing their safety and tolerability in Onychomycosis patients.
- Investigation of Terbinafine Hydrochloride nanosponges may lead to more convenient and patient-friendly treatment options.
- Overcome the limitations of traditional approaches.

- The scope of studying the effect of Terbinafine Hydrochloride nanosponges in the treatment of Onychomycosis disease encompasses a multidisciplinary approach, including pharmaceutical formulation, nanotechnology, pharmacology, microbiology, and dermatology.

EXPERIMENTAL WORK:

a. Literature Review
b. Selection of Drug
c. Selection of Polymers
d. Procurement of Drug and Excipients
e. Preformulation Studies
  1. Characterization of Drug
    - Melting Point
    - Purity of Drug by IR
    - λ max determination
    - Calibration Curve of Drug
  2. Drug Excipients interaction (Compatibility Studies)]
    - IR Spectroscopy
f. Formulation of Nanosponges
g. Evaluation of Nanosponges

LITERATURE REVIEW:

I. **Subhash Chandra Bose, Nagaraju Ravoru (2016)** explained the procedure of nanosponge and anti-fungal tablet formulation. In this research article step by step evaluation parameters are explained. It also includes various characteristics of nanosponge and nanosponge containing tablets.

II. **Venkatesh et.al (2018)**explained significant steps in overcoming certain problems such as toxicity, poor bioavailabilty and release of drug in a predictable fashion and how the tiny particulates of nanosponges circulate in the body. As Nanosponge have unique ability to entrap the drug moieties, they offers a merit of desire results. This novel approach can serve very effective action.

III. **Anjali S. Kumar et al (2018)** presented a review on the study of Clotrimazole nanosponge formulation by using ethyl cellulose polymer with an PVA as a co-polymer by an emulsion solvent diffusion method and the prepared nanosponge are analyzed, evaluated. The shape of nanosponges were determined by Scanning Electron Microscopy which are spherical in shape.

DRUG PROFILE:

TERBINAFINE HYDROCHLORIDE:

Category: Anti-fungal drug

Chemical name: Lamisil

IUPAC Name: N-(6, 6- dimethyl-2-heptane-4-ynyl)-N-methyl-(E)- hydrochloride

Molecular formula: $C_{21}H_{25}N$, HCl

Weight: 327.9 g/mol

BCS class: II

Dose: 250 mg once daily orally

Description: White crystalline powder.

Melting point: 204-208°C

Solubility: It is practically water insoluble, sparingly soluble in acetone and freely soluble in methanol & ethanol.

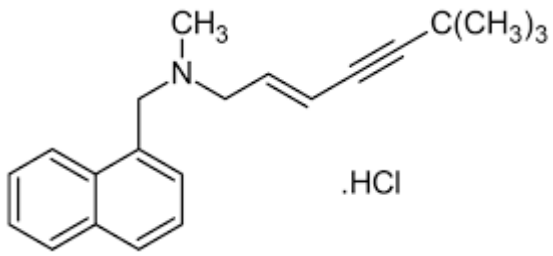
Pka: 7.10

Log P: 5.9

Half life: 8 hrs

Bio-availability: 45%

Structural formula:



Mechanism of action: Terbinafine inhibits squalene epoxidase, decreasing the synthesis of ergosterol. Causes accumulation of toxic amount of squalene results in death of fugal cell.

Metabolism: At least 7 distinct Cytochrome P450 enzymes break it down into 10 metabolites; the most significant appear to be CYP2C9, CYP2A2, and CYP3A4.

Route of Elimination: It is approximately 80% eliminated in urine, while the remainder is eliminated in feces.

Toxicity: Overdose dose with Terbinafine is rare, however symptoms are vomiting, nausea, dizziness, abdominal pain, frequent urination, headache.

Side effects: Rash, headache, dizziness, abdominal pain, stomach ache

Contraindications: Due to the possibility of anaphylaxis, is contraindicated in people who have history of allergic response to oral Terbinafine. [10-19]

EXCIPIENTS PROFILE:

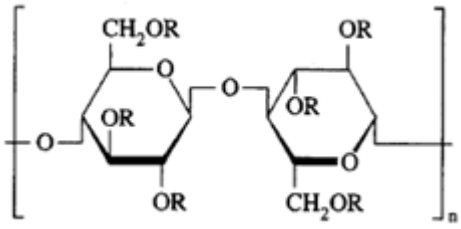
HPMC(HYDROXY PROPYL METHYL CELLULOSE) :

Synonyms : HPMC, Methocel Hydroxy Propyl Cellolose

Molecular formula: $C_{56}H_{108}O_{30}$

Chemical name: (2-Hydroxypropyl)-beta-cyclodextrin

Structural formula:



R represents -H, $-CH_3$

Molecular weight: 1261.4 g/mol

pH: pH 5.5-8.0 for 1% w/w aq. Solution

Solubility: It is soluble in cold water, forming a viscous colloidal solution, insoluble in chloroform, ethanol (95%) and ether, but soluble in mixture of methanol and dichloromethane and mixture of water and alcohol.

Melting point: 225-254°C

Applications:

- Paints and coating
- Food and cosmetics
- Used as a suspending and thickening agent in topical formulation, particularly in ophthalmic preparations.[19,20]

EHYL CELLULOSE:

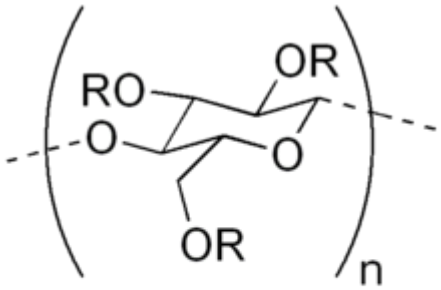
Synonyme: Cellulose, Ethyl ether, Ethylactate cellulose

Chemical name: Ethocel, Triethyl cellulose

IUPAC Name: Methyl 4-O-methyl-hexopryranosyl-(1-4)-2,3,6-tri-O-ethyl-hexopyranoside

Molecular formula: $C_{20}H_{38}O_{11}$

Structure:



R = H or CH_2CH_3

Molecular weight: 454.5 g/mol

pH: Neutral

Log P: 5.50

Melting point: 240-255°C

Applications:

- Thin film coating material for coating paper, vitamin, medical pills
- Thickeners in cosmetics and industrial processes
- Food emulsifier [21]

PROCUREMENT OF DRUG:

Terbinafine: QUE PHARMAPVT. LTD. Gujarat. (Gift Sample)

METHODS OF PREPARATION OF NANOSPONGES:

i. Emulsion Solvent Diffusion Method
ii. Solvent Evaporation Method
iii. Ultrasound assisted synthesis
iv. Freeze Drying Method
v. Micro-emulsion Method
vi. Sonication-Assisted Method
vii. Co-acervation Method, etc.[21,22,23,24]

EMULSION SOLVENT DIFFUSION METHOD:

A general stepwise overview of the formulation process for nanosponges:

i. **Polymer Selection:** The first step in formulating nanosponges is to select a suitable polymer. Various polymers can be used, such as, polymeric materials like polyvinyl alcohol (PVA) or polyethylene glycol (PEG). The polymer should be bio compatible, have good drug-loading capacity and be capable of forming a porous structure.
ii. **Cross linking Agent:** A cross linking agent is used to form a stable three-dimensional network within the polymer matrix. Common cross-linking agent such as Dichloromethane as a specific cross-linking polymer.
iii. **Polymer Dissolution**: The selected polymer is dissolved in a suitable solvent, such as water, to form a polymer solution. The solvent choice depends on the polymer's solubility and compatibility.
iv. **Drug Incorporation**: The desired antifungal drug is added to the polymer solution and mixed thoroughly. The drug should be soluble in the solvent to achieve uniform distribution within the nanosponge matrix.
v. **Cross-linking:** Once the drug is incorporated, a cross-linking agent is added to the polymer-drug

mixture. The cross-linking agent helps to form the porous structure by creating inter-molecular cross-links within the polymer matrix. The cross-linking reaction can be initiated by adjusting pH, temperature.

vi. **Polymer Precipitation:** After cross-linking, the polymer-drug mixture is typically precipitated by adding the solution drop-wise into a non-solvent, such as ethyl acetate. Precipitation facilitates the formation of nanosponge nanoparticles.

vii. **Washing and Purification:** The obtained nanosponge nanoparticles are then washed multiple times with a suitable solvent to remove any residual cross-linking agent, unreacted drug, or impurities. Washing helps ensure the purity and safety of the nanosponge formulation.

viii. **Drying:** The purified nanosponges are typically subjected to a drying process to remove residual solvents and obtain a solid form suitable for further use or formulation. Drying methods can include vacuum drying and air-drying, depending on the characteristics of the nanosponges.[23,24]

Sr no.	Contents	B1	B2	B3	B4	B5	B6
1	Terbinfine Hydrochloride (mg)	250	250	250	250	250	250
2	Polyvinyl alcohol (mg)	200	300	200	300	200	300
3	Ethyl cellulose (mg)	200	200	400	400	600	600
4	HPMC (mg)	200	200	200	300	300	300
5	Dichloromethane (ml)	20	20	20	20	20	20
6	Purified Water (ml)	100	100	100	100	100	100

Table 1: Formulation table

EVALUATION OF FORMULATED NANOSPONGES:

i. **Particle Size and Size Distribution:** Average particle size and size distribution can be determined using method Electron Microscopy zeta potential.

ii. **Encapsulation Efficiency:** Measurement of the quantity of drug encapsulated inside the nanosponges, usually accomplished by removing the drug from the formulation of the nanosponge and measuring the drug content.

Encapsulation efficiency (EE%) is calculated by,

(Total drug added – free non-entrapped drug) / Total drug added

iii. **Drug Loading Capacity**: An evaluation of the maximum quantity of drug that can be put into nanosponges is made by dividing the maximum amount of drug by the formulation's total weight.

Drug Loading Capacity (%)is calculated by,[25]

(Weight of the entrapped drug inside the nanosponges/ Total weigh of the drug) x100

iv. **Morphology:** Using methods like Scanning Electron Microscopy (SEM) analyse the morphology and surface properties of nanosponges.

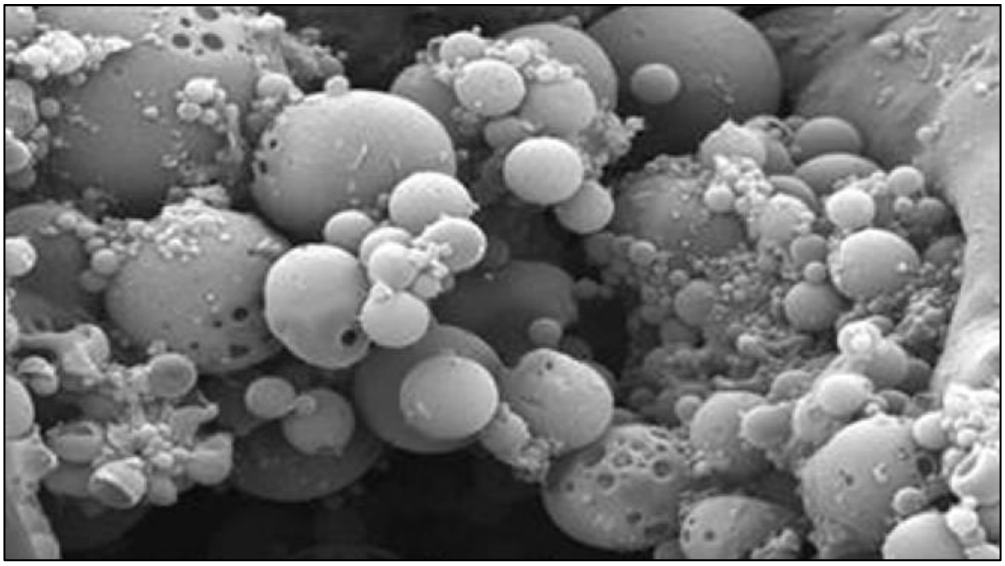


Fig.4: SEM of Antifungal Nanosponge

v. **Stability:** Evaluation of the nanosponge formulation's physical and chemical stability over time, taking into account aspects such particle size changes, drug degradation, and aggregation. Accelerated stability testing under different storage conditions may be used in stability research.[26,27]

These evaluations help characterize the properties, performance, and safety of nanosponge formulations in NDDS and provide valuable information for optimizing their design and application in clinical settings.[28]

INSTRUMENTS:

Sr.no	Instruments
1.	Electronic balance
2.	Hot plate
3.	Mechanical stirrer
4.	Orbital shaking incubator
5.	Infrared Spectrophotometer
6.	Desiccator
7.	Hot air oven
8.	Tablet compression machine
9.	Monsanto hardness tester
10.	USP type II (Paddle) dissolution apparatus

Table 2: Instruments

PREFORMULATION STUDY OF OPTIMIZED NANOSPONGES:

An effective tableting operation depends on the flow characteristics of powders. To provide effective mixing and tolerable weight consistency for the compressed tablets, a good flow of the powder is required. The bulk density, tapped density, angle of repose, compressibility index and Hausner's ratio are among the flow property measurements.

1. BULK DENSITY:

Bulk density is defined as the relationship between bulk mass and bulk volume. The initial volume of the powder material is measured, the weight of the powder is put into a 50 ml measuring cylinder, and the bulk density is determined using the formula below.

$$\text{Mass Bulk density} = \frac{\text{Mass}}{\text{Volume}} \times 100$$

Unit for bulk density is g/ml.

2. TAPPED DENSITY:

It is the proportion of tap volume to bulk mass. An essential evaluation parameter known as "tapped density" is obtained by setting a graduated cylinder with a known mass of powder. As soon as the powder bed volume reaches a minimum volume, it is done mechanically. Formula is used to compute the Tapped density.

$$\textbf{Tapped density} = \frac{\textbf{Weight of Powder}}{\textbf{Tapped volume of Powder}}$$

3. ANGLE OF REPOSE:

It is defined as the Pile surface of Powder. The drug and the mixture were poured through the walls of a funnel that was set so that its bottom tip was exactly 1.0 cm above a hard surface in order to measure the angle of repose. The medicine was poured up until the point at which the surface of the pile's upper tip contacted the funnel's lower tip.

The equation below was used to determine the angle of repose,

$$\theta = \tan^{-1} (h/r)$$

Where, h = height of pile in cm;

r = radius of pile in cm

θ = Angle of repose

4. CARR'S INDEX:

Bulk and tapered densities are used to calculate the Carr's index. It is the proportion of bulk density to tapped density. To obtain the Carr's Index, the taped density is minimised by the bulk density, divided by the taped density, and multiplied by 100.

When the Carr's Index is less than or equal to 10, the property is said to be free-flowing, and when it is larger than 10, the property is said to be poor-flowing.

$$\textbf{Carr's index} = \frac{\textbf{Tapped density - Bulk density} \times 100}{\textbf{Tapped density}}$$

5. HAUSNER'S RATION:

The Hausner's ratio is a proximate indicator of powder flow simplicity. It is determined using the using the formula, [29]

$$\text{Hausner's ratio} = \frac{\text{Tapped density}}{\text{Bulk density}}$$

6. FTIR STUDIES:

FT-IR studies are important to check the structural bonds and there ranges for further formulation approach. It is check to confirm purity of drug by comparing practical spectra with standard spectra.[30]

FORMULATION OF TERBINAFINE HYDROCHLORIDE NANOSPONGES LOADED TABLETS:

Formulating a Terbinafine Hydrochloride drug-containing nanosponge tablet involves several steps, such as:

I. **Excipient Selection:** Excipients are selected to aid in the tablet formulation process. These include binders, diluents, disintegrants, lubricants and other excipients needed to ensure tablet integrity, flowability, and dissolution.

II. **Addition of drug** : The nanosponges containing Terbinafine Hydrochloride are mixed with selected excipients and API to prepare the tablet. The drug loading in the tablet is adjusted to achieve the desired dosage strength.

III. **Tablet Compression**: The direct compression blend of the nanosponge drug mixture and excipients are compressed using a tablet press machine to form tablets of the desired shape and size.

IV. **Quality Control**: Quality control tests are performed on the final tablets to ensure their quality, uniformity and compliance with regulatory standards. These tests include as physical characterization, content uniformity, dissolution testing.[29]

Sr.no	Ingredients	Quantity
1.	Terbinafine Hydrochloride Nanosponge (B2)	280mg
2.	Magnesium Stearate	60 mg
3.	Microcrystalline Cellulose	160 mg

Table 3: Formulation table of Tablet

EVALUATION OF TERBINAFINE HYDROCHLORIDE CONTAINING NANOSPONGES TABLETS:

Terbinafine Hydrochloride nanosponges tablet is evaluated for following parameters

1. Weight variation test
2. Hardness test
3. Friability test
4. Thickness test
5. In – Vitro dissolution studies

1. Weight variation test:

It is preferable for each individual tablet in a batch to be uniform in weight, a minor variance in the weight of the individual tablet is possible. 20 tablets from each batch were weighed using an analytical electronic balance in order to evaluate weight fluctuation, and the mean weight was computed. Not more two tablets fails to pass the test.

2. Hardness test :

Tablet hardness is defined as the force necessary to break a tablet in a diametric compression test. Tablets need to be strong enough to survive the mechanical shocks of handling during production, packaging, and shipment. Using a Monsanto Hardness Tester, the tablets' hardness was assessed. It is formulated in kg/cm^2. By taking mean of 3 readings hardness is tested.

3. Friability test :

A friability test is run to assess the tablets' resistance to abrassion during handling, packing, and transportation. Tablets' degree of friability was assessed using a Friabilator. The friabilator was loaded with ten preweighed tablets and ran for 4 minutes at 25 rpm. The tablets were removed, dusted, and reweighed after 100 rotations. The following formula was used to calculate the percentage of tablets that were friable.

$$\text{Friability} = \frac{(\text{Initial weight of tablet} - \text{Final Weight of tablet})}{\text{Initial Weight of Tablet}} \times 100$$

4. Thickness :

The thickness of a tablet is determined by a Vernier Calliper. It is expressed in millimetres. Each batch of three tablets was randomly chosen, and the mean and standard deviation values were calculated.

5. In – Vitro dissolution studies :

Dissolution studies are conducted to determine the potential impact of formulation and process variables on a drug's bioavailability and to show how well the preparation works in vivo. It is a method for researching drug release from solid dosage forms. Using USP type II dissolving test equipment, the rate of Terbinafine Nanosponge tablet release from was calculated. 900 ml pH 6.8 phosphate buffer were used for the dissolution test, which was carried out at 37.5 ± 0.5°C and 50 rpm. Every hour for a total of 12 hours, a 5 ml sample of the dissolving medium was taken out of the dissolution equipment and replaced with brand-new dissolution media.The sample was filtered through Whattman filter paper and diluted to an appropriate phosphate buffer of pH 6.8. These solutions absorbance was determined at 283 nm using a UV-visible spectrophotometer. Parameter for in vitro dissolution study:

Dissolution apparatus: USP Type II (Paddle) Dissolution medium: 900 ml of phosphate buffer (pH 6.8)

Rotation speed and Temperature: 50 rpm and 37°C ±0.5 °C

Time interval=1 hour

Sample volume withdrawn: 5ml [30]

RESULTS

EVALUATION OF TERBINAFINE HYDROCHLORIDE:

I. Organoleptic properties :

Sr.no	Properties	Observations
1	Colour	White or almost white
2	Odour	Odourless
3	Form	Crystalline

Table 4: Organoleptic properties

II. Melting point :

Terbinafine Hydrochloride	Refernce	Observed
	195-198 °C	197.7 °C

Tablet 5: Melting Point

III. Calibration curve :

Sr.no.	Concentration (µg/ml)	Absorbance (λ max 283 nm)
1	2	0.123
2	4	0.260
3	6	0.371
4	8	0.501
5	10	0.599

Table 6: Callibration curve

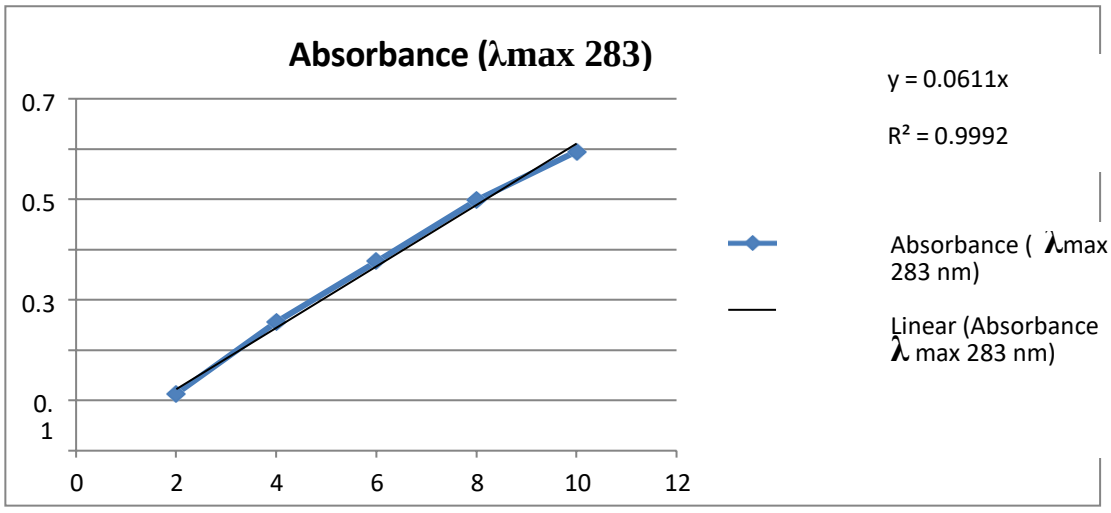


Fig no. 5: Calibration graph of Terbinafine Hydrochloride

IV. FTIR STUDIES:

Table 7: Ranges of FTIR

Peaks	Range of functional group	Observed
C-N bands	1350-1000	1356.99
C-H (aliphatic structure)	3000--2800	2973.47
Enes	900-650	772.63
C-H (1,2,3 trisubstituted)	780	775.26

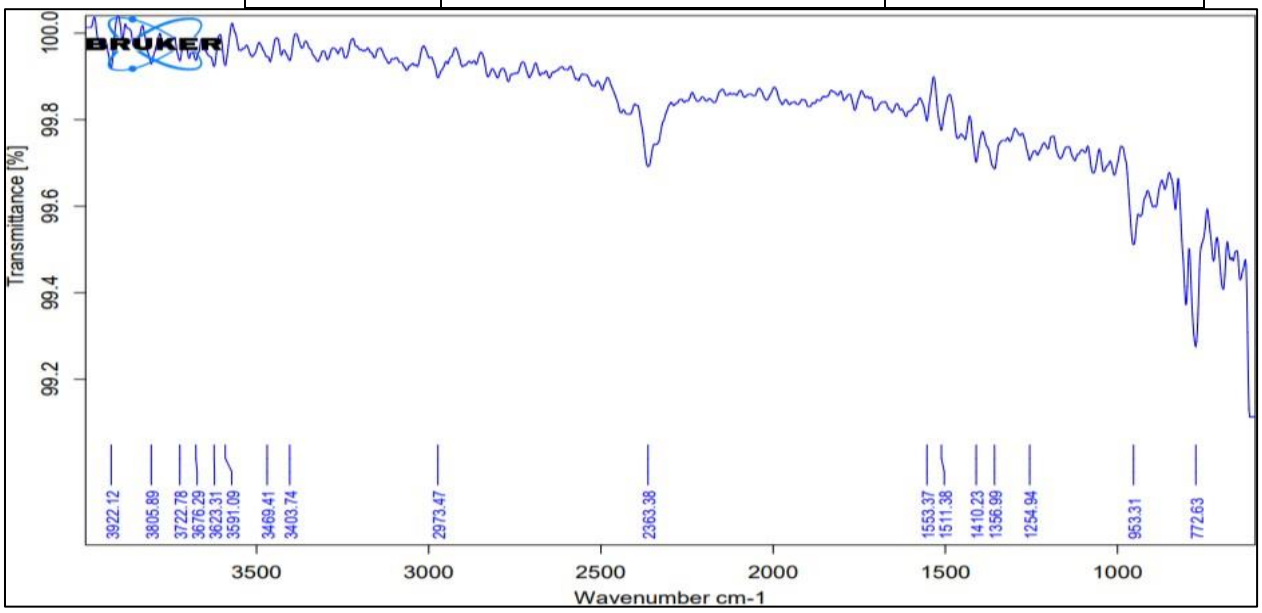


Fig 6: IR of Terbinafine Hydrochloride

EVALUATION OF NANOSPONGE

In-Vitro Studies:

	)rug + EC+ HPMC (%)					
Time (hrs)	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**
0	0	0	0	0	0	0

1	7.27	20.58	11.12	11.55	12.10	13.24
2	9.80	26.45	18.58	19.22	19.79	20.12
3	14.85	38.65	25.56	26.12	27.20	25.98
4	28.20	53.42	40.58	43.52	46.54	41.33
5	53.62	68.50	59.89	63.20	57.22	61.23
6	67.58	**84.25**	78.89	73.25	76.37	75.18

Table 8: In-Vitro Studies

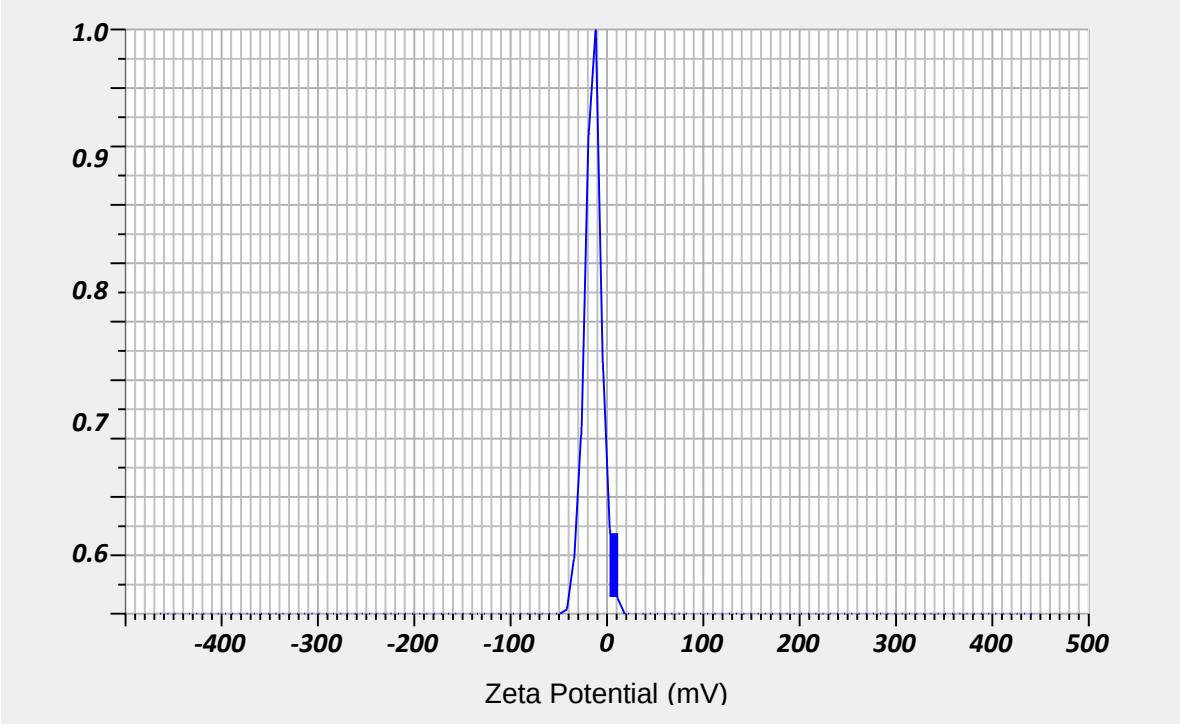
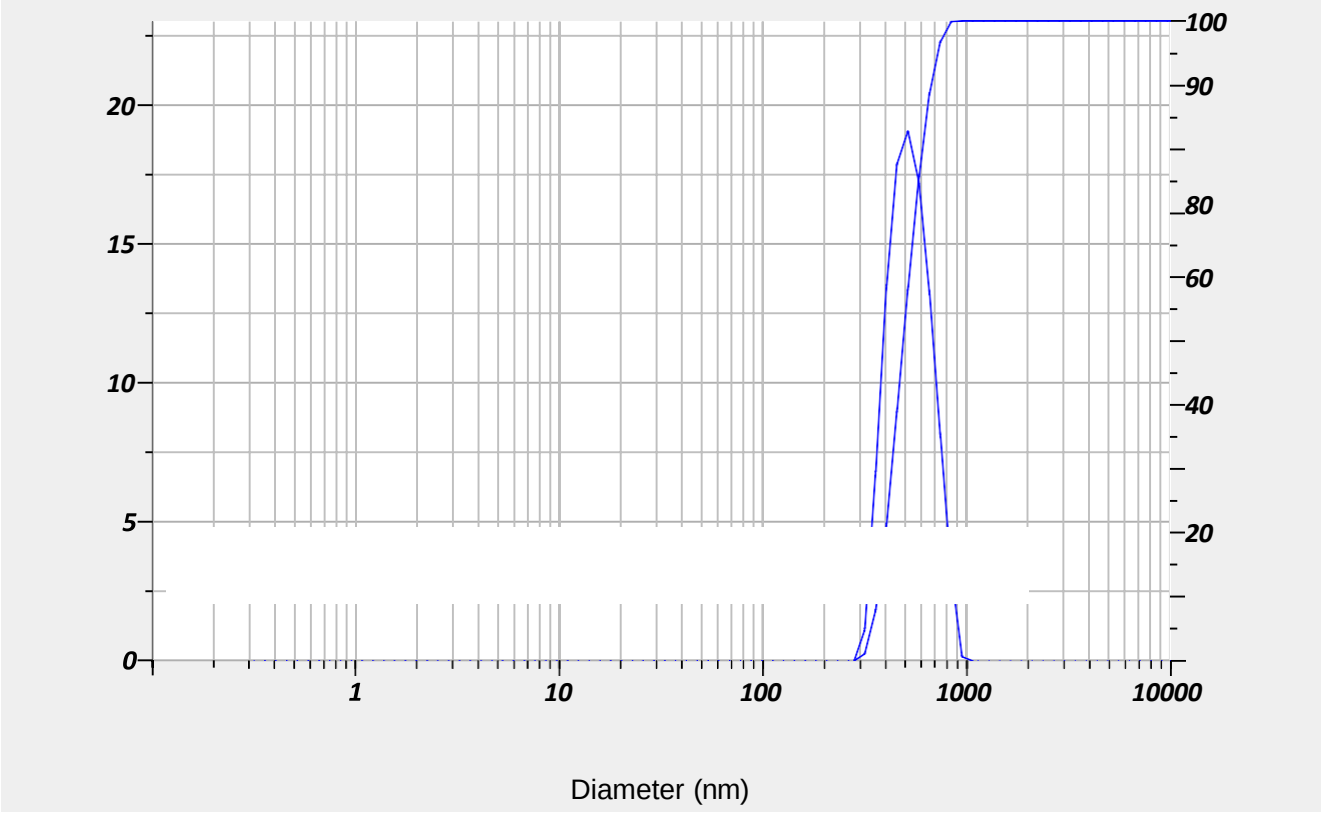


Fig 7: Zeta Potential of Optimized Batch **B2**

Table 9: Evaluation table of nanosponges

Batches	Entrappment Efficiency (%)	Practical yield (%)	Particle size (nm)	Polymer disperse index (Mw/Mn)	Zeta potential (mv)
B1	77 %	79 %	225	0.430	-9.0
B2	**90%**	**78.40 %**	**232**	**0.961**	**-15.2**
B3	85 %	74.23 %	515	0.540	-10.5
B4	69.52 %	70 %	524	0.260	-2.6
B5	79 %	80.85 %	316	0.703	-3.0
B6	64 %	82 %	412	0.978	-7.8

Fig : Particle Size of Nanosponge



PREFORMULATION STUDIES FOR TABLET PREPARATION

Preformulation studies	Bulk density	Tapped density	Angle of repose	Carr's index	Hausner's ratio
B 2	0.580	0.633	23.4 °C	7.73	1.08

Table 10: Flow properties of Terbinafine Hydrochloride Powder

EVALUATION OF TARBINAFINE HYDROCHLORIDE TABLETS

Formulation	Weight variation test	Thickness test (mm)	Hardness test (kg/cm^2)	Friability test (%)	Disintegration time test (min)	Dissolution rate (%)
B 2	complies	4.11± 0.15	5.65±0.20	0.755	25±1.30	91

Table 11: Evaluation of tablets

CONCLUSION

In conclusion, the "Formulation and Evaluation of Nanosponge Containing Terbinafine Hydrochloride" as an Antifungal drug prepared by Emulsion Solvent Diffusion Method, successfully demonstrated the potential of nanosponges as a promising drug delivery system for Terbinafine Hydrochloride. The formulation process involved the selection of suitable polymers, optimization of various formulation parameters and characterization of the nanosponges. The nanosponges exhibited a high drug entrapment efficiency, which indicates their ability to effectively encapsulate Terbinafine Hydrochloride. The particle size analysis facilitating their potential for enhanced drug delivery.

Moreover, In-vitro drug release studies demonstrated sustained release of Terbinafine Hydrochloride from the nanosponge formulation, which is advantageous in maintaining therapeutic drug levels over an extended period. This sustained release pattern could potentially minimize the dosing frequency and improve patient compliance.

Overall, this project successfully formulated and evaluated nanosponges containing Terbinafine Hydrochloride. The developed nanosponge formulation demonstrated improved drug entrapment efficiency, sustained release profile and enhanced antifungal activity.

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