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Formulation and Evaluation of Medicated Nail Lacquer for the Treatment of Onychomycosis

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Abstract: ***Onychomycosis is fungal infection of toenails or fingernails caused by a fungal microbe that invades the nail. The purpose of the present investigation is to formulate and evaluate an antifungal nail lacquer for treatment of onychomycosis. These formulations require high concentration of active agents to be incorporated for effective therapy because of their low efficacy. Topical therapy would be an attractive alternative approach in the treatment of onychomycosis as it is found to be capable of overcoming most of the limitations of systemic administration and targeting the drug at its site of action, with minimum interactions and adverse effects. Ciclopirox was chosen as a model drug, the formulations were prepared with permeation enhancers Salicylic acid. Then, these lacquers were compared for drying time, nonvolatile content drug content, drug diffusion and anti -microbial studies. From Diffusion studies across artificial membrane, For 12 hours, diffusion tests were conducted on all of the formulations using an artificial membrane Formulation F6 showed percentage drug release 93.2%.Thebest nail lacquer formulation was selected based on drug diffusion trials.***

Keywords: Onychomycosis, Ciclopirox, permeation enhancers.

I. INTRODUCTION

1) Onychomycosis is fungal infection of toe nails or fingernails caused by a fungal microbe that invades the nail. The purpose of the present investigation is to formulate and evaluate an antifungal nail lacquer for treatment of onychomycosis. These formulations require high concentration of active agents to be incorporated for effective therapy because of their low efficacy. Topical therapy would be an attractive alternative approach in the treatment of onychomycosis as it is found to be capable of overcoming most of the limitations of systemic administration and targeting the drug at its site of action, with minimum interactions and adverse effects.
2) Human nails do not have only protective and decorative role, but can also be considered as analternative pathway for drug delivery, especially in nail diseases such as onychomycosis or psoriasis.
3) The human nail consists of,Nail matrix or the root of the nail,Nail bed ,Eponychium or cuticle, Paronychium Hyponychium, Nail plate, and Lunula
4) The inadequate research and knowledge regarding the properties of keratinized nail plate,the nailbed and the nail matrix cause da lesser focus on ungual system.
5) The human nail plate consists of three layers; the dorsal and intermediate layer derived from the matrix and the ventral layer from nail bed. The intermediate layer is three - quarter of the whole nail thickness & consists of the soft keratin. The upper layer, dorsal, is only a few cell layer thick but consists of hard keratin, with relatively high sulphur content, mainly the form of amino acids cysteine, which constitutes 94% by weight of nail.
6) Nail polish or nail varnish is applied to human fingernails or toenails to decorate and/or protect the nail plate. Conventional nail lacquers have been used as cosmetics since along time for beautification and protection of nails.

II. MATERIALS AND METHODS

A. *Chemicals*

Sr.No.	Name of Ingredients	Category	Suppliers
01	Ciclopirox	API	Shree Sadguru Hitech Pvt Ltd, Pune
02	Nitrocellulose	Film forming Polymers	Shree Sadguru Hitech Pvt Ltd, Pune
03	Ethyl cellulose	Film forming Polymers	Shree Sadguru Hitech Pvt Ltd, Pune
04	Dibutyl pthalate	Plasticizer	Shree Sadguru Hitech Pvt Ltd, Pune
05	Salicylic acid	Permeation Enhancer	Shree Sadguru Hitech Pvt Ltd, Pune
06	Acetone	Solvents	Shree Sadguru Hitech Pvt Ltd, Pune
07	Ethanol	Solvents	Shree Sadguru Hitech Pvt Ltd, Pune

B. Equipments

Sr.No.	Instruments	Manufacture and suppliers
1	Digital balance	Electro lab , Mumbai
2	FT-IR	Perkin Elmor FT/IR-4100 type A
3	Desiccator	Technico, Delhi
4	Franz diffusion cell	Murthys, Hyderbad
5	UV/Visible Spectro-photometer	Lab India 3200, Mumbai
6	pH meter	Electro lab, Mumbai
7	Hot air oven	Electro lab, Mumbai

C. Methodology

1) Preformulation Studies

Preformulation is the first step in the rational development of dosage form of a substance and is defined as an investigation of physical and chemical properties of drug substance alone and when combined with excipients. This initial learning phase is known as pre- formulation. The basic purpose of the pre-formulation activity is to provide a rational basis for the formulation approaches, to minimize the chances of success in formulating an acceptable product and to ultimately provide a basis for optimizing drug product quality and performance. The first step in any formulation activity is careful consideration of a complete physico chemical profile of the active ingredients available, prior to initiating a formulation development activity.

2) Important Parameters evaluated during Preformulation Studies

Evaluation of API

Physical characterization of API

- Description: It is the initial evaluation during pre-formulation studies which assess the color of the substance. This was only a descriptive test.
- Solubility: Aqueous solubility is an important physicochemical property of drug substance, which determines its systemic absorption and in turns its therapeutic efficacy.
- Melting point: Construction of Standard Curve of Ciclopirox

Determination of absorbance maximum (λmax) -A solution of Ciclopirox containing the concentration 10 µg/ml was prepared in methanol; UV spectrum was taken using Double beam UV-VIS spectrophotometer. The solution was scanned in the range of 200 – 400 nm.

3) Preparation Calibration Curve

Ciclopirox drug 10 mg was weighed accurately and then it dissolve in the 10 ml methanol in the 10 ml of volumetric flask, then to make (1000 µg/ml) standard stock solution. Then from it take 1 ml of stock solution was taken from the 10 ml volumetric flask, to make (100 µg/ml) standard stock solution. 1 ml stock solution was taken in another 10 ml volumetric flask and then final concentration were prepared 2, 4, 6, 8, 10, and 12 µg/ml with solvent methanol. The absorbance of standard solution was determined using UV/ VIS spectrophotometer at 305 nm.

UV- Spectra of pure Ciclopirox was obtained from UV- Spectrophotometer and the absorption maximum was found to be 305 nm.

D. Method of Preparation of nail lacquer Formulation of nail lacquer

Ingredients (%)	F1	F2	F3	F4	F5	F6
Ciclopirox	3	3	3	3	3	3
Nitrocellulose	6	6	6	6	6	6
Ethyl cellulose	5	10	15	-	-	-
Dibutyl pthalate	-	-	-	5	10	15
Salicylic acid	26	21	16	26	21	16
Acetone	10	10	10	10	10	10
Ethanol (QS)	50 ml	50 ml	50 ml	50 ml	50 ml	50 ml

The formulation trials were done as per formula given in Table 6.4 the mixture of Ciclopirox and Nitrocellulose was dissolved in Ethyl cellulose in the measured quantity using a magnetic stirrer at 100 rpm speed. To above clear solution required quantity of Dibutyl phthalate, Salicylic acid, and acetone were mixed thoroughly and made up to the volume to 50 ml with the help of ethanol. The ready nail lacquer was poured into a glass bottle with a tiny mouth and a plastic screw lid.

E. Evaluation of Ciclopirox Nail Lacquer Nonvolatile content

10 ml of sample was taken in a Petri dish and initial weights were recorded. After an hour at 105°C in the oven, the Petri dish was taken out, allowed to cool, and then weighed. The weight differential was noted. The triple reading average was recorded.

Drying time

A sample film was applied to a Petri plate using a brush. The duration required to generate a dry-to-touch film was timed using a stopwatch.

Smoothness to flow

The sample was poured into a glass plate from a height of 1.5 inches, spread out, and allowed to rise vertically before being visually inspected for film smoothness.

Gloss

After applying a sample of nail lacquer on the nail, the shine was compared to cosmetic nail lacquer that is sold in stores.

Viscosity

Using spindle number three at 20 rpm and a Brookfield viscometer at room temperature, the viscosity was measured.

Drug content estimation

By precisely dissolving 1 ml of nail lacquer in methanol, the drug content of the product was ascertained. After a suitable dilution, the absorbance at 305 nm was measured with a UV- visible spectrophotometer to determine the drug concentration.

Diffusion studies across artificial membrane Determination of antimicrobial activity Stability study

Stability studies of nail lacquers were carried out as per ICH guidelines. Samples were stored at temperature 40 ± 2°C/75 ± 5% RH for 3 month. Next, the samples were analyzed for non-volatile content, drying time, gloss, and smoothness of flow, drug content, and diffusion over artificial membrane.

III. RESULTS AND DISCUSSION

A. Preformulation Study

A preformulation study for Ciclopirox pure drug is performed. Following results of preformulation studies are carried out, which were carried out as per methods, explained in the methodology section.

Test	Specification / limits	Observations
Colour	White crystalline solid	White crystalline solid
Odor	Characteristic	Characteristic

B. Melting Point

Drug	Observed M.P. (^{o}C)	Reported M.P. (^{o}C)
Ciclopirox	139	135-143

C. Solubility Study of Ciclopirox

The solubility of Ciclopirox in different solvent Water, Methanol, Ethanol, and Acetone was determined.

Solvents	Solubility (mg/ml)
Ethanol	0.78
Water	0.03
Acetone	0.36

D. Determination of Wavelength of Maximum Absorption

The wavelength of maximum absorption was found to be 305 nm.

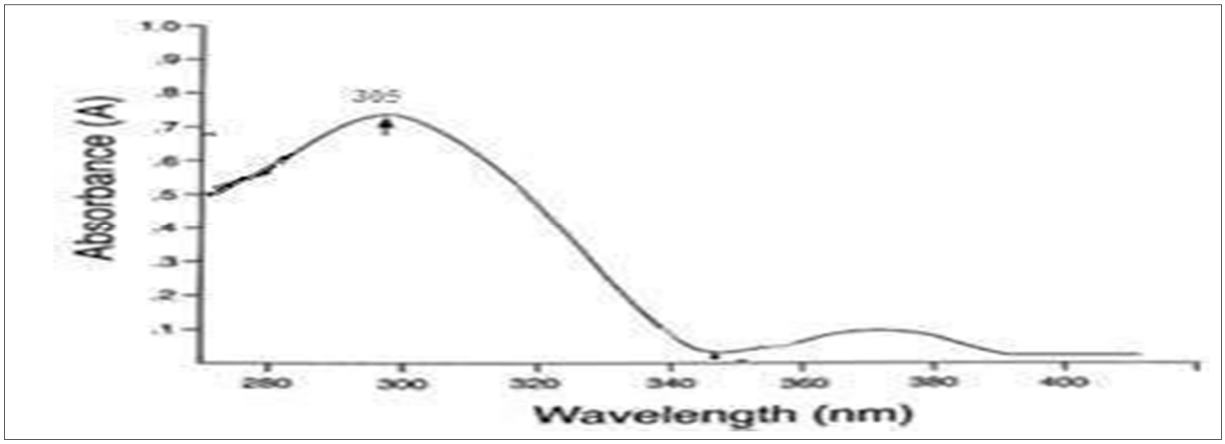


Figure : UV Absorption spectra of Ciclopirox

E. Development Of Standard Curve Of Drug

A solution of Ciclopirox containing the concentration 10 µg/ml was prepared in methanol; UV spectrum was taken using Double beam UV-VIS spectrophotometer. The solution was scanned in the range of 200 – 400 nm.

Concentration (µg/mL)	Absorbance
0	0
2	0.172
4	0.318
6	0.459
8	0.626
10	0.776
12	0.897

Table: standard Calibration curve of drug

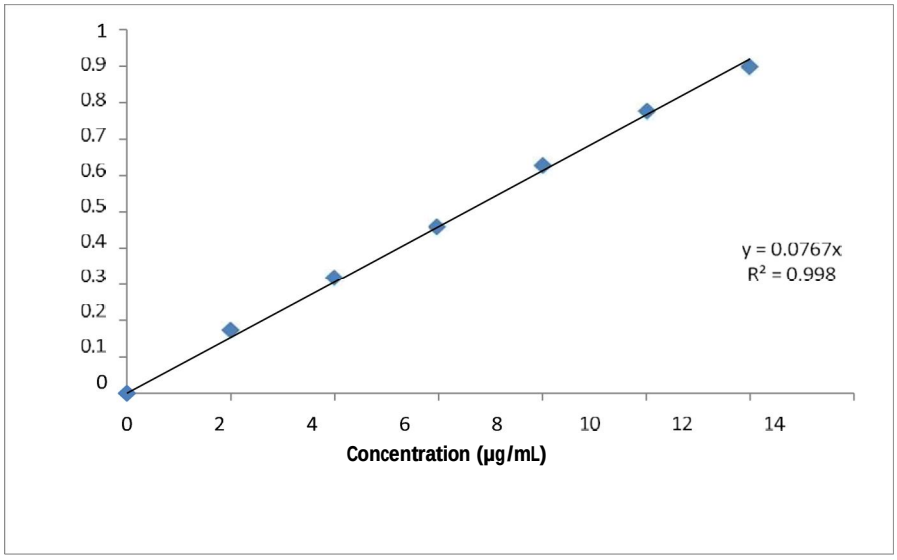


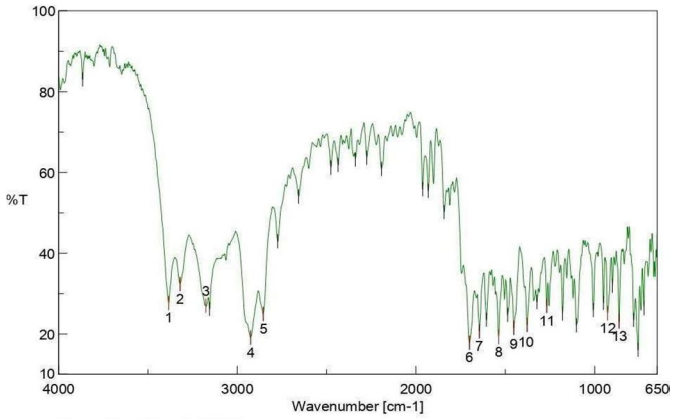
Fig : Calibration curve of Ciclopirox at 305 nm

F. Drug and Polymer Compatibility Study of Ciclopirox by FT-IR

In FTIR spectra the peaks of physical mixture was compared with the original spectra. Same peaks were observed, there is no possible molecular interaction between the drug and the polymer.

All the reference IR peaks of the pure drug Ciclopirox were also present in the spectra of mixture of drug- polymer and drug-permeation enhancer- excipients as mentioned in the above spectral data.

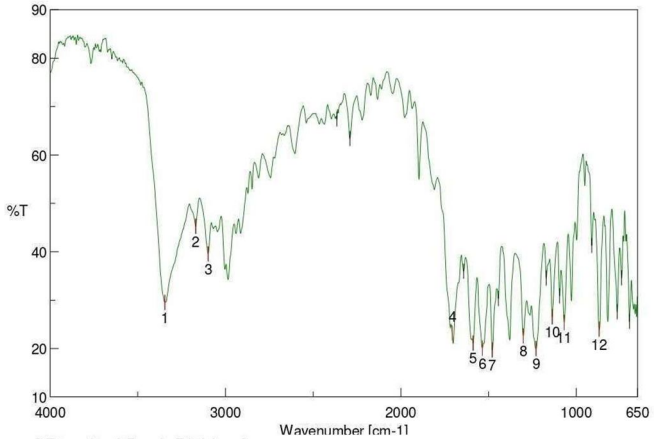
So FTIR study showed that there is no interaction between drug and permeation enhancer. So the drug and permeation enhancer are compatible. The IR spectrums were given in the Figures 7.3 and 7.4 respectively



[Result of Peak Picking]

No.	Position	Intensity	No.	Position	Intensity
1	3374.45	27.6685	2	3329.86	32.3722
3	3166.18	26.9562	4	2924.48	19.1762
5	2864.12	24.9302	6	1689.94	17.8307
7	1654.99	20.5983	8	1535.89	19.2337
9	1443.11	21.4546	10	1377.99	22.2089
11	1257.96	26.9345	12	937.583	25.0653
13	852.979	23.0492			

Figure : FTIR Spectra of Ciclopirox



[Result of Peak Picking]

No.	Position	Intensity	No.	Position	Intensity
1	3345.89	29.508	2	3170.4	45.2376
3	3099.05	39.5285	4	1707.66	23.2279
5	1588.09	21.1235	6	1535.06	20.0653
7	1479.13	19.6983	8	1301.72	22.549
9	1229.4	19.9701	10	1136.83	26.53
11	1069.33	25.3767	12	869.739	23.9778

Figure : Compatibility study of Drug and Excipients by FTIR

G. Evaluation Parameters of Formulation

The intended film formation was demonstrated by all formulations, and the flow was adequately smooth. A thin layer resulting from the full evaporation of volatile matter revealed the desired amount of nonvolatile stuff; the data were shown in Table No. 7.5. There was a 52-59 second drying time found. All formulations showed rapid drying rate. ie less than 60 seconds. The data were mentioned in Table No.7.6.

H. Nonvolatile Content

The non- volatile content of all formulations has been reported in the Table No.7.5 given below

Formulation code	Non- volatilecontent (%)
F1	34±0.32
F2	41±0.48
F3	38±0.42
F4	37±0.51
F5	39 ±0.47
F6	36±0.40

Table : Nonvolatile content of nail lacquers

I. Drying Time

All formulations showed rapid drying rate. ie less than 60 seconds. The data were mentioned in Table No.7.6.

FormulationCode	Drying time (sec)
F1	53
F2	55
F3	53
F4	58
F5	59
F6	52

Table : Drying time of nail lacquers

J. Smoothness to flow and Gloss

As seen in Fig., both of these criteria were determined to be satisfactory. It was found that nails lacquer spread and created a smooth, even coating when it was applied to a glass plate. The applied lacquer's sheen was similar to that of a cosmetic sample that was sold, indicating that it was accepted cosmetically.

Figure: Smoothness to flow and Gloss of nail lacquer

K. Viscosity

The viscosity of the sample ranged from 135 to 147 Centipoise and it was observed that between 130 to 150 Centipoise the product was clear and glossy. Furthermore, the adhesion and flow properties were good within this viscosity range. Viscosity outside this range produces clouding and decreases gloss which will not be cosmetically acceptable.

Formulation code	Viscosity
F1	135
F2	139
F3	142
F4	137
F5	147
F6	140

Table : Viscosity of nail lacquers

L. Percentage Drug Content Determination

The percentage drug concentration of all lacquers was found to be sufficient, ranging from 85.55 to 99.02%, as Table No. 5 illustrates. The results showed that the highest percentage of drug content was 99.02% (F6), while the lowest percentage was 85.55% (F2). A formulation with drug content of more than 90% indicates a high concentration of drug and guarantees that the chosen ingredients and formulation techniques will not compromise the drug's stability. High drug content also gives the assurance that, a good therapeutic outcome can be expected.

Formulation Code	Drug content(%)
F1	91.50 ±0.46
F2	85.55±0.45
F3	86.25 ± 0.35
F4	94.28 ± 0.52
F5	95.80 ± 0.45
F6	99.02 ± 0.56

Table : Percentage Drug Content

M. Diffusion studies Across Artificial Membrane

For 12 hours, diffusion tests were conducted on all of the formulations using an artificial membrane (cellophane membrane -0.8µm). Each formulation was subjected to diffusion studies in accordance with Table No. 7.9. Formulation F6, the best nail lacquer formulation, was selected based on drug diffusion trials.

Time (hr)	Cumulative percentage drug release(±SD*)					
	F1	F2	F3	F4	F5	F6
0	0	0	0	0	0	0
1	2.4±0.8	3.2±0.4	3.4±0.82	3.7±8.30	3.03±2.31	4.5±9.81
2	3.37±2.46	3.4±3.37	5.08±8.7	5.3±8.89	5.05±8.62	12.0±9.24
3	9.93±2.26	9.15±0.6	15.6±8.4	15.9±0.51	9.87±6.64	34.4±2.36
4	15.5±0.66	13.9±5.3	33.1±2.5	33.3±3.43	17.2±3.28	41.7±3.84
5	37.2±3.41	28.2±1.62	41.1±0.5	41.1±7.75	31.2±0.49	52.9±7.56
6	43.1±1.57	36.3±1.69	47.5±6.5	56.5±6.62	42.7±6.81	65.0±1.98
8	49.6±7.31	47.9±7.5	55.4±8.7	63.4±8.19	55.0±1.86	77.6±9.91
10	54.9±0.51	56.3±5.54	62.8±9.2	75.4±3.49	66.5±5.52	88.2±8.59
12	74.3±4.26	69.7±0.21	75.7±3.5	91.1±6.13	86.8±7.76	93.2±1.58

Table : *In vitro* diffusion studies across artificial membrane

Invitro drug release is carried out for batch F6, with increase the concentration of polymer concentration the percentage of drug release was, 93.2% in 12 hrs.

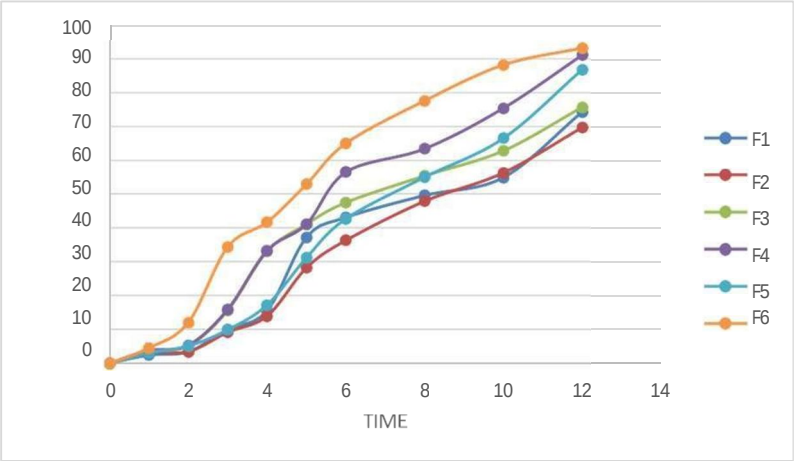


Fig: In vitro drug release data of Ciclopirox Nail Lacquer (F1-F6)

N. Zero order release kinetic of Ciclopirox Nail Lacquer

When the data is plotted as cumulative % drug release versus time, if the plot is linear then the data obeys zero- order release Kinetics, with a slope equal to K0. The best match for the Higuchi equation is 99% in zero order.

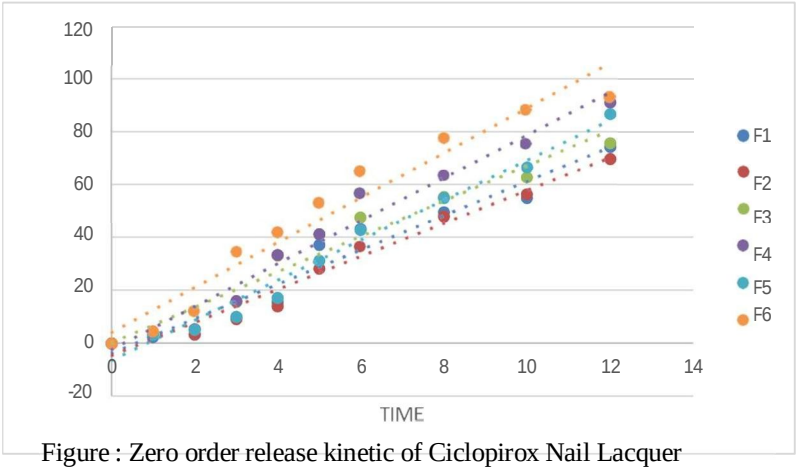


Figure : Zero order release kinetic of Ciclopirox Nail Lacquer

O. Anti-microbial study

The zone of inhibition for the pure medication and the enhanced formulation were compared (Figure 7.11). The pure drug (A) exhibited a zone of inhibition of 25 mm, whereas the improved formulation (B) displayed a zone of inhibition of 23.4 mm. These findings demonstrated the formulation's susceptibility to the Candida albicans bacteria.

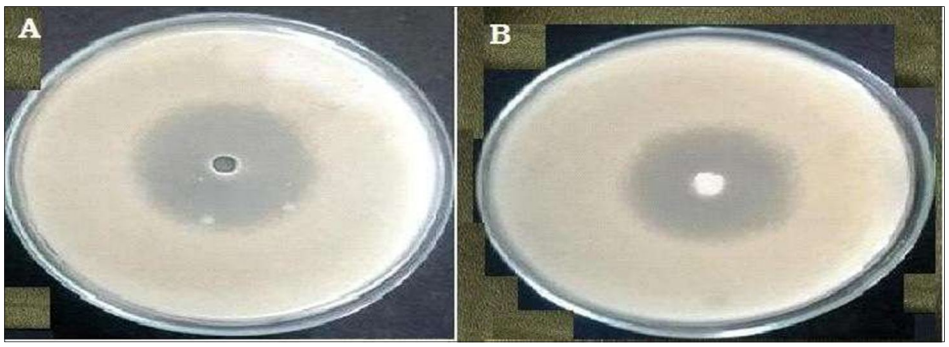


Figure : Zone of inhibition of Formulated Nail Lacquer

P. Stability Studies

To ascertain a product's shelf life and storage conditions, stability studies were employed. For three months, F6 underwent expedited stability studies as part of this inquiry. With the appropriate adjustments, accelerated stability investigations were carried out in compliance with ICH requirements. The investigations were conducted over a three- month period to confirm changes in physical features like non-volatile content, drying time, percentage drug content, and drug diffusion under three distinct higher temperature conditions (40±2°C). Table No. 7.10 reports the findings.

When the formulations were assessed after the stability charge, it was discovered that the non-volatile content, drying time, percentage of drug content, and drug diffusion had not changed significantly from the pre-stability research results. As a result, it was determined that the formulations met the ICH norms for stability compliance.

Parameter	Initial	After Stability Study
Non-volatile content	36 ±0.47	35 ± 0.38
Drying time(sec)	52	53
Drug content	99.02	98.70
% drug Release	93.2 ±1.58	92.98 ±1.45

Table: Stability studies data of F6

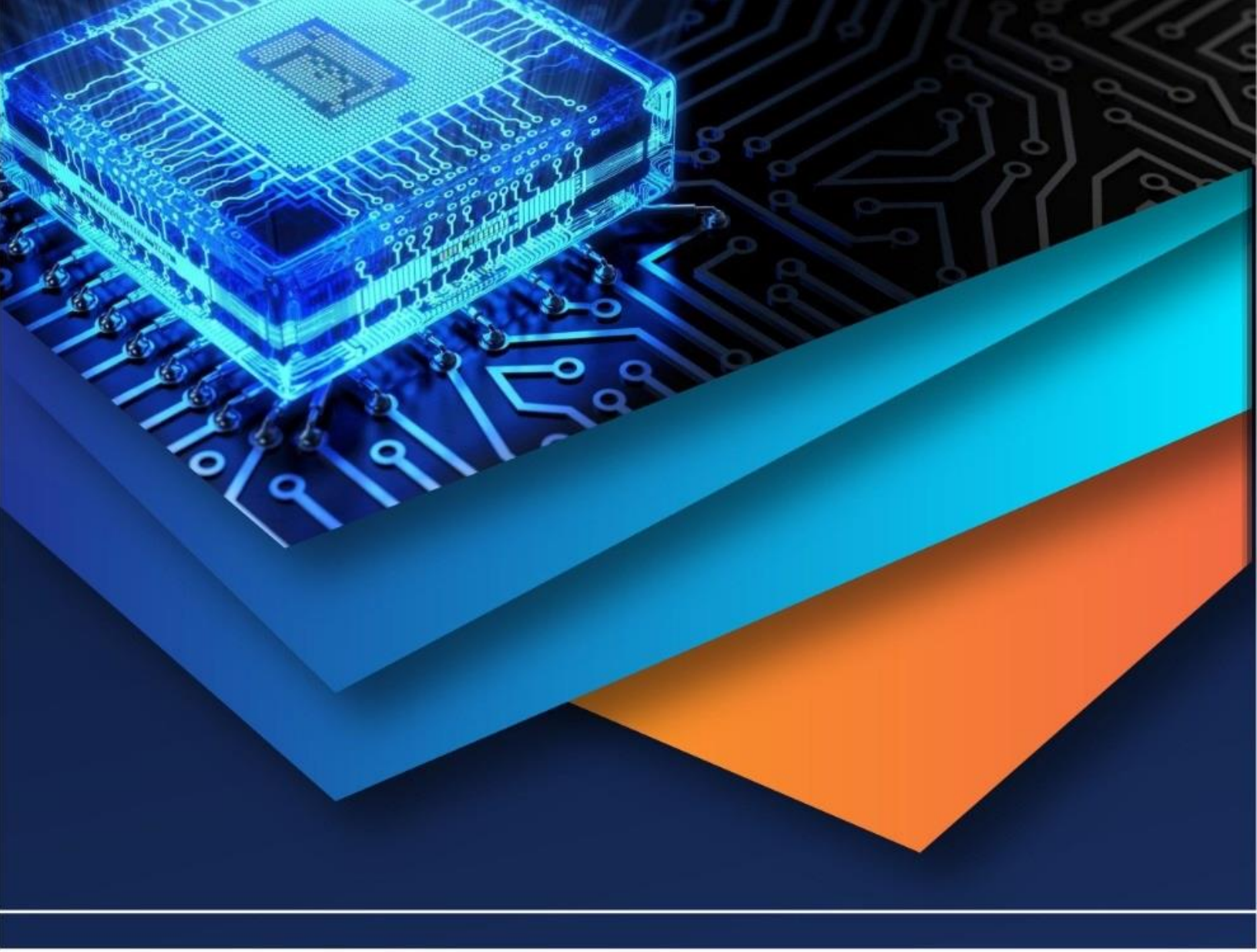
IV. CONCLUSION

1) The purpose of the present investigation was to formulate and evaluate the Ciclopirox nail lacquer as an ungual drug delivery system for the treatment of onychomycosis.
2) Ciclopirox was chosen as a model drug, the formulations were prepared with permeation enhancers Salicylic acid. Then, these lacquers were compared for drying time, nonvolatile content drug content, drug diffusion and anti - microbial studies.
3) From the FTIR studies, it was concluded that the drug and the excipients used in the formulations were compatible with each other.
4) All formulations showed good film formation, drying time, smooth flow, and required volatile content.
5) Microbial study results proved that the formulations are sensitive to the microorganism *Candida albicans.*
6) The stability tests showed that the formulations were stable at 40°c for 3 month.
7) The results obtained from the *in vitro* studies indicate that formulation F6 showed a complete drug release which sustained over 12 hours.
8) The percentage non-volatile content of F6 formulation was found to be 36±0.40.The desired amount of non-volatile matter was seen with complete evaporationof volatile matter.
9) F6 formulation showed rapid drying rate.
10) The viscosity of F6 formulation was observed as 140.so this formulation was clear and glossy.
11) The adhesive strength of F6 formulation compared with marketed sample and it possess adequate adhesive strength on applied nail surface.
12) 99.02% of drug content was found in F6. So a good therapeutic outcome can be expected.
13) From Diffusion studies across artificial membrane, For 12 hours, diffusion tests were conducted on all of the formulations using an artificial membrane (cellophane membrane -0.8µm). Formulation F6 showed percentage drug release 93.2%. The best nail lacquer formulation was selected based on drug diffusion trials.
14) The formulation F6 was selected as the optimized nail lacquer formulation based on drug diffusion studies
15) Stability study data showed that there was no much change in the values after stability test. It was concluded that the formulations were found to possess stability compliance requirements as per ICH guidelines.

REFERENCES

[1] Gupchup GV, Zatz JL. Structural characteristics and permeability properties of the human nail: A review. j Cosmet Sci 1999;50:363-385.
[2] Rajendra VB, Baro A, Kumari A, Dhamecha DL, Lahoti SR, Shelke SD. Transungual Drug Delivery: An Overview. J Appl Pharm Sci 2012;2(1):203- 09
[3] Patel RP, Naik SA, Patel NA, Suthar AM. Drug delivery across human nail. Int J Curr Pharm Res Vol1Issue1 2009;01:01-7
[4] Suryavanshi KA, Basru PR, Katedeshmukh RG. Review on Nail Transungual Drug Delivery System. Am. J. PharmTech Res. 2012;2(5):222- 04.
[5] Sabreen J, Divyakumar B, Kiran B. Preungual drug delivery systems of terbinafine hydrochloride nail lacquer. Asian J Pharm 2008;02:53-06.
[6] Shirwaikar AA, Thomas TA, Lobo R, Prabhu KS. Treatment of Onychomycosis:An Update. Ind J Pharm Sci 2008 Nov-Dec;70(6):710-14.

[7] Lalit SK, Panwar SA, Darwhaker G, Jain DK. Formulation and Evaluation of Ciclopirox Amphiphilogel. Der Pharmacia Lettre, 2011; 3 (5):125-31
[8] Kobayashi Y,Komastu T,Sumi M,Numajiri S,Miyamoto M,Kobayashi D,Sugibayashi K,Morimoto Y.In vitro permeation of several drugs through the human nail plate:Relationship between physicochemical properties and nail permeability of drugs.Eur.J.Pharm.Sci.2004;21:471-477.
[9] Alam G, Singh MP, Singh A, Vishwakarma DK, Patel R, Srivastava SP. Trans- ungual drug transport: advancement and challenges. J Pharm Res 2012;5(5):2574- 79.
[10] Walters,K.A, Flynn,G.L, Marvel,J.R.Peneration of the human nail plate:the effects of vehicle pH on the permeation of miconazole. J.Pharm.Pharmaco.1985;37:498- 499.
[11] Pravin DC, Shilpa PC, Pramod KK, Bothiraja C. Drug delivery through nail 2006 cited 2010Nov 29. Available from: URL: http://www.pharmainfo.net/reviews/drug- delivery-through-nail- review
[12] Boni E. Elewski, Onychomycosis: Pathogenesis, Diagnosis, and Management, Clin. Microbiol. Rev. July 1998 vol. 11 no. 3 415-429
[13] Jason A. Winston , Jami L. Miller, Treatment of Onychomycosis in Diabetic Patients, Clinical.diabetesjournals.org 2008 Nov-Dec; 70(6): 710–714
[14] Westerberg DP, Voyack MJ. Onychomycosis: current trends in diagnosis and treatment. American family physician. Dec 2013. **88** (11): 762–70.
[15] Weinberg JM, Koestenblatt EK, Tutrone WD, Tishler HR, Najarian L. Comparison of diagnostic methods in the evaluation of onychomycosis. J. Am. Acad. Dermatol. 2003. 49 (2): 193–7
[16] Elewski, BE; Hay, RJ. Update on the management of onychomycosis: highlights of the Third Annual International Summit on Cutaneous Antifungal Therapy. Clinical infectious diseases: an official publication of the Infectious Diseases Society of America. August 1996. 23 (2): 305–13
[17] Phillip R, And Bassler M, Treating Onychomycosis, University of Michigan Medical School, Ann Arbor, Michigan, Am Fam Physician. 2001 Feb 15;63(4):663-673.
[18] Cohen PR, Scher RK. Topical and surgical treatment of onychomycosis. J. Am. Acad. Dermatol. 1994; 31:S74–S77.
[19] Gupta AK, Lynde CW, Jain HC, Sibbald RG, Elewski BE, Daniel CR, Watteel GN, Summerbell RC. A higher prevalence of onychomycosis in psoriatics compared with non- psoriatics: A multicentre study. The British journal of dermatology. 1997. 136 (5): 786–789.



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