**RESEARCH ARTICLE**

# Fabrication and Characterization of Tolnaftate Loaded Topical Nanoemulgel for the Treatment of Onychomycosis

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**ABSTRACT**

The core objective of this work was to formulate nanoemulgel containing tolnaftate loaded for sustained delivery of the treatment of onychomycosis. Onychomycosis was not regarded as a serious infection until quite recently. The oral antifungal therapy for onychomycosis usually lasts long and brings a set of adverse effects, especially hepato-toxicity and drug interactions. The incidence of onychomycosis in with more prevalent in warm humid climates topical therapy is usually prescribed only in mild cases. It prevails among around 5% of the total world population and affects toenails much more than fingernails. The incidence of onychomycosis with more prevalent in warm humid climates so an attempt has been made to develop nanoemulsion containing tolnaftate. Formulations were optimized by factorial design. Developed formulations were evaluated and characterized for **d**rug content-96.72, *in-vitro* release study-68.42%, SEM study. Based on the drug content, *in-vitro* release study, and SEM study, the optimized formulation was converted into nanoemulgel. The developed topical nanoemulgel was evaluated for the determination of pH 6.60, determination of spreadability 17.77 g.cm/sec, measurement of viscosity 12350 cp, drug **c**ontent Study 96.52%, *in-vitro* drug release **s**tudy 70.42% found to be effective and producing a sustained effect.

**Keywords:** Tolnaftate, Factorial design, Nanoemulsion, Nanoemulgel, Onychomycosis.

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**Conflict of interest:** None

## INTRODUCTION

Onychomycosis was not regarded as a serious infection until quite recently. It started gaining attention after the US Food and Drug Administration approved terbinafine for oral therapy in 1996. This was succeeded by the approval of ciclopirox for topical therapy in 1999. It prevails among around 5% of the total world population and affects toenails much more than fingernails. The incidence of onychomycosis in India ranges from 0.5 to 5% with more prevalence in warm humid climates. It is mostly caused by dermatophytes, which belong to one of the three genera (*Trichophyton, Epidermophyton,* and *Microsporum*), with *Trichophyton rubrum* being the most prevalent. Physical manifestations include brittleness of nails, distortion of nail structure and discoloration.[1] Treatment options for onychomycosis are quite limited mainly due to deep-seated infection and the impermeable nature of nail. The impermeability of nail can be attributed to the highly stable and strong disulfide linkages and hydrogen bonds in the keratin network. With hard keratin fibers and globular proteins to hold them tight, nail plate is one of the toughest biological barriers to exist. The oral antifungal therapy for onychomycosis usually lasts long and brings a set of adverse effects, especially hepato-toxicity and drug interactions. With their limited availability at the site of action, the prescribed dose or frequency is escalated. This not only further increases the associated side effects but also the treatment cost. On the contrary, topical therapy is devoid of such side effects and is convenient to patients but its effect is hampered by rigid keratin structure of the nail which is quite difficult to penetrate.[2] Topical therapy is usually prescribed only in mild cases. Also, the conventional topical formulations get easily removed or washed off from the nail plate while doing chores. Many techniques have been devised to facilitate topical delivery to the nail like mechanical, physical and chemical.[3] Generally, these techniques involve applying topical formulations after therapy to enhance permeation. Mechanical therapy involves complete nail avulsion or nail abrasion with filing the affected part of the nail. The physical treatment modalities include high-end techniques like iontophoresis, phonophoresis, photodynamic therapy or laser therapy. The chemical treatment involves

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the addition of chemical penetration enhancers to the topical formulation, which interferes with the chemical bonding in nail structures and facilitates permeation by breaking the existing bonds. Sometimes the combinations of these techniques with oral or topical therapy are prescribed. But every technique comes with its own set of issues and there still does not exist a method in the market which can provide the desired result in less time. This leaves a lot of space for developing novel strategies to bring about efficient drug delivery and patient compliance. The focus has shifted from nail lacquers and painful surgical nail removal to nanotechnology for facilitating delivery.[4] Nanoparticles promote deeper nail penetration, drug retention, and controlled release. Nanoparticles can ensure site-specific drug release over prolonged duration to maintain the desired therapeutic drug concentration. Encapsulation of oral antifungal drugs in nanoparticles can also reduce toxicity issues. Apart from nanoparticles, research work on other novel systems have also been carried out like *in-situ* gels, microemulsion, polymeric films etc. Such novel systems delivered through an appropriate dosage form will serve as useful vehicles for nail drug delivery. This review will focus on discussing such novel strategies which hold a lot of potential for treating persistent issue like onychomycosis.[5]

## MATERIALS AND METHODS

### Materials

Tolnaftate was purchased from Yarrow Chem products. Almond oil - Nice Chemicals Pvt. Ltd. Tween 80 - Nice Chemicals Pvt. Ltd. Propylene Glycol - Omega Laboratory chemical. Methyl Paraben - Nice Chemicals Pvt. Ltd Propyl Paraben - Nice chemicals Pvt. Ltd. Butylated hydroxytoulene(BHT) - Omega Laboratory chemical. Carbopol 940Sigma Aldrich, Chennai all other regents used are of high purity.

### Methodology

*Preparation of standard stock solution*

An accurately weighed quantity of 100 mg tolnaftate was taken in a 100 mL volumetric flask and dissolved using 5 mL of methanol. Finally, the volume was made with methanol upto 100 mL to produce 1-mg/mL of solution.[6]

*Scanning*

A series of concentrations i.e., 1, 2, 3, 4, 5 µg/mL were prepared using the above stock solution and scanned between 200 to 400 nm. The absorption maxima obtained was 257 nm was selected and used for further studies. [7]

*Preparation of calibration curve*

A standard solution containing 1-mg/mL of tolnaftate was prepared in methanol by dissolving 50 mg of pure tolnaftate in 50 mL of methanol. From this solution, working standard solution of concentration 1 to 5 µg/mL of tolnaftate was prepared by dilution with methanol. The absorbance of the solution was measured at 257 nm against blank. All spectral absorbance measurement was made on Shimadzu 1800 UV–visible spectrophotometer (Figure 1).[8]

**Table 1:** Composition of nanoemulsion

| *Formulation code* | *F1(g)* | *F2(g)* | *F3(g)* | *F4(g)* |
|---|---|---|---|---|
| *Ingredients* | | | | |
| Tolnaftate | 1 | 1 | 1 | 1 |
| Almond oil (v/v) | 1 | 2 | 3 | 4 |
| Tween 80 (v/v) | 5.25 | 5.25 | 5.25 | 5.25 |
| Propylene glycol (v/v) | 0.5 | 1 | 1.5 | 2 |
| Methyl paraben | 0.03 | 0.03 | 0.03 | 0.03 |
| Propyl paraben | 0.01 | 0.01 | 0.01 | 0.01 |
| BHT(Butylated hydroxytoulene) | 0.1 | 0.1 | 0.1 | 0.1 |
| Water | 100 | 100 | 100 | 100 |

### Formulation and Evaluation of Nanoemulsion of Tolnaftate

*Formulation of nanoemulsion of tolnaftate*

Nanoemulsion of tolnaftate were prepared with the help of High-pressure homogenizer mixer using different ratio of almond oil with the drug. Three trial formulations were carried out and are shown in Table 1 (F1 – F4).[9]

- *Preparation of aqueous phase 'A'*

Accurately weighed quantity of propylene glycol was added into distilled water (800c).

- *Preparation of oil phase 'B'*

Weighed quantity of almond oil and tween 80 mixed together by maintaining hot condition, simultaneously accurately weighed quantity of tolnaftate was added into it then the addition of methyl paraben, propyl paraben and BHT in it.[10]

- *Incorporation of the solution 'A' in dispersion 'B'*

Both phases were mixed properly with the help of high-pressure homogenizer, maintaining the respective rpm.

### Experimental Design and Optimization of Formulation

A $2^2$ factorial design was applied for optimization using Design Expert software version 11, Stat-Ease, Inc. The experimental design involved a total of four formulations (F1 to F4) in which the concentration of almond oil ($X_1$) and concentration of surfactant propylene glycol ($X_2$) were selected as independent variables (Factors) and drug content in % ($R_1$) and *in-vitro* drug release ($R_2$) were selected as dependent variables (responses) at two different levels; -1 as low and +1 as high level (Figure 2). The desired optimized formulation were chosen based on the produced results (Table 2 and 3).

### Characterization Studies of Nanoemulsion of Tolnaftate

*Drug content*

Drug content study was done to determine the amount of the drug present in a certain quantity of the formulation. Took 1-g of the formulation into 10 mL volumetric flask, added methanol, shaken well, and made up the volume with methanol. The volumetric flask was kept for 2 hours and shaken well in a shaker to mix it properly. The solution was passed through the filter paper and filtered the mixer then measured absorbance by using a spectrophotometer at 257 nm.[11]

$$\text{Drug content} = \frac{\text{Sample absorbance}}{\text{Standard absorbance}} \times 100$$

*In-vitro drug release study*

The *in-vitro* drug release studies of the nanoemulsion were carried out on diffusion cells using dialysis membranes. This was clamped carefully to one end of the hollow glass tube of the dialysis cell. Emulsion (1 gm) was applied on to the surface of the dialysis membrane. The receptor chamber was filled with freshly prepared PBS (pH 7.4) solution. The total amount of gel-filled in the tube to solubilize the drug. The receptor chamber was stirred by a magnetic stirrer. The samples (1-mL aliquots)were collected at suitable time interval sample were analyzed for drug content by UV visible spectrophotometer at 257 nm after appropriate dilutions.[12]

*Scanning electron microscopy*

The morphology of nanoemulsion can be determined by scanning electron microscopy (SEM). SEM gives a three-dimensional image of the particle. The samples were examined at different magnifications at suitable accelerating voltage, usually 3.0 kV.[13]

**Formulation and Evaluation of Nanoemulgel of Tolnaftate**

Among three formulations of nanoemulsion prepared with the help of high-pressure homogenizer mixer (F1 – F3) based on the *In-vitro* drug release, the optimized formulation (F1) containing ratio of (1). Almond oil was found to be effective and that formulation was selected as the optimized formulation for the conversion of nanoemulgel formulation. [14]

**Preparation of Gel**

The weighed quantity of carbopol 934 was mixed in distilled water (4000c) further, addition of triethanolamine to maintain the desired pH range of the solution. The uniformity in the stirring was maintained and then the gel was kept in the refrigerator for 24 hours.[15]

**Preparation of Emulgel**

Further incorporation of nanoemulsion containing 1% drug was incorporated to obtain nanoemulgel.[16]

**Characterization of Nanoemulgel of Tolnaftate**

*Determination of pH*

pH of the formulation was determined by using a digital pH meter. pH meter electrode was washed by distilled water and then dipped into the formulation to measure pH and this process was repeated 3 times.[17]

*Determination of spreadability*

Glass slides with standard dimensions (length of 6.0 cm) were taken. Topical gel formulation was placed on one side of the glass slide and sandwiched with the help of another slide. Remove the adhering gel on the outer surface of the glass slides by wiping. Slides are fixed in a stand that only allows the upper slide to slip off freely without any disturbance by the force of weight (20 g) tied to it. The time taken for the movement of upper slide to the distance of 6.0 cm was measured. Measurement of spreadability was done in triplicate and calculated by using the following formula:[18]

Spreadability = (Weight×Length)/Time

Where,

S=Spreadability

m=Weight tied to the upper slide (20 g)

l=Length of the glass (6.0 cm)

t=Time taken in seconds

The viscosity of the formulated batches was determined using a Brookfield Viscometer with spindle 63 with various rpm. The formulation whose viscosity was to be determined was added to the beaker and was allowed to settle down for 30 minutes at the assay temperature (25 ± 1ºC)

**Table 2:**Calibration value

| *S.no* | *Concentration (µg/mL)* | *Absorbance* | *Standard deviation* |
|---|---|---|---|
| 1. | 0 | 0 | 0 |
| 2. | 1 | 0.1242 | ±.001 |
| 3. | 2 | 0.2460 | ± 0.001 |
| 4. | 3 | 0.4684 | ± 0.012 |
| 5. | 4 | 0.6806 | ± 0.0011 |
| 6. | 5 | 0.8424 | ± 0.001 |

* n=3 (Average of 3 determinations)

*Drug content study*

Drug content study was done to determine the amount of the drug present in a certain quantity of the formulation. Took 1-g of the formulation into 10 mL volumetric flask, added methanol, shaken well, and make up the volume with methanol. The volumetric flask was kept for 2 hours and shaken well in a shaker to mix it properly. The solution was passed through the filter paper and filtered the mixer then measured absorbance by using a spectrophotometer at 257nm.[19]

$$\text{Drug content} = \frac{\text{Sample absorbance}}{\text{Standard absorbance}} \times 100$$

*In-vitro drug release study*

The *in-vitro* drug release studies of the nanoemulgel were carried out on diffusion cell using dialysis membrane. This was clamped carefully to one end of the hollow glass tube of dialysis cell. Emulgel (1 gm) was applied on to the surface of the dialysis membrane. The receptor chamber was filled with freshly prepared PBS (pH 7.4) solution. Total amount of gel filled in the tube to solubilize the drug. The receptor chamber was stirred by magnetic stirrer. The samples (1-mL aliquots) were collected at suitable time interval sample were analyzed for drug content by UV visible spectrophotometer at 257 nm after appropriate dilutions.[20]

## RESULTS AND DISCUSSION

**Preformulation Studies**

*Determination of solubility profile*

Solubility of drug (Tolnaftate) was found to be freely soluble in distilled water and organic solvents.[21]

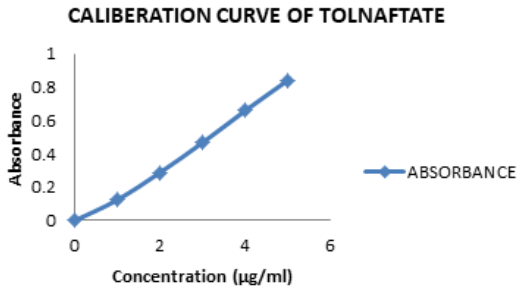


**Figure 1:** Calibration graph

**Table 3:** Factors and responses of factorial design

| | | *Factor 1* | *Factor 2* | *Response 1* | *Response 2* |
|---|---|---|---|---|---|
| *Std* | *Run* | *A:Almond oil* | *B:Propylene glycol* | *Drug Content* | *In-vitro drug release* |
| | | mL | mL | % | % |
| 4 | 2 | 2 | 1 | 94.62 | 64.42 |
| 3 | 1 | 1 | 0.5 | 91.91 | 58.42 |
| 2 | 4 | 3 | 2 | 98.53 | 69.93 |
| 1 | 3 | 4 | 1.5 | 96.72 | 68.42 |

ANOVA for selected factorial model

*Calibration curve*

Tolnaftate is an antifungal drug. It is used for topical drug in the treatment of cutaneous diseases. The proposed analytical method is simple and accurate for the estimation of tolnaftate. The drug samples were analyzed by UV spectroscopy using methanol as solvent as shown in Table 2. We concluded that the suggested method showed high linearity in organic solvent as shown in Figure 1. Moreover, this method is simple and inexpensive and it can be employed for the routine quality control of tolnaftate in pharmaceutical formulations.

*Experimental design and optimization of formulation*

In total, 4 formulations were designed based on 2 level factorial design and characterized for drug content and *in-vitro* drug release. Drug content was carried out for all the developed formulations and based on the runs formulation containing the highest drug content (F4) was selected for further studies. The *in-vitro* drug release was carried out for the developed tolnaftate loaded nanoemulsion. Among all the developed formulations with 2 level factorial design, a formulation containing high level of almond oil and propylene glycol (F4) showed better-optimized response.

Drug content and *in-vitro* drug release was shown in Table 3

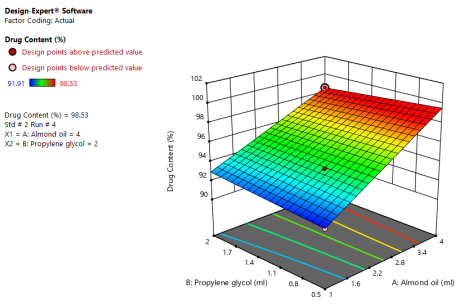


**Figure 2:** ANOVA for selected factorial model

Factor coding is Coded. Sum of squares is Type III – Partial

The model F-value of 2374.47 implies the model is significant as shown in Table 4. There is only a 1.45% chance that an F-value this large could occur due to noise.

*p-values* less than 0.0500 indicate model terms are significant. In this case A is a significant model term. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

Factor coding is coded sum of squares is type III - Partial

The model F-value of 3301.46 implies the model is significant. There is only a 1.23% chance that an F-value this large could occur due to noise.

*p-values* less than 0.0500 indicate model terms are significant. In this case A, AB are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

**Evaluation of Nanoemulsion of Tolnaftate**

*Drug content*

The drug content of formulation was shown in Table 4. The percentage drug content of all prepared nanoemulsion formulations (F1, F2, F3,F4) was found to be in the range of 91 to 96%.[22]

*In-vitro drug release study*

The *in-vitro* release of developed Nanoemulsion formulations were carried out by diffusion method. Among all the three developed formulations, formulation (F1) ratio of almond oil and drug (Tolnaftate) showed sustained drug release of 58.42 ± 0.72 in 8 hours when compared with other formulations (F2) 64.42 ± 0.76 and (F3) 68.42 ± 0.64 (Figure 4). [23]

**Table 4:** Response 1: Drug Content

| *Source* | *Sum of Squares* | *df* | *Mean Square* | *F-value* | *p-value* | |
|---|---|---|---|---|---|---|
| Model | 24.31 | 2 | 12.16 | 2374.47 | 0.0145 | significant |
| A-Almond oil | 24.11 | 1 | 24.11 | 4709.39 | 0.0093 | |
| B-Propylene glycol | 0.0000 | 0 | | | | |
| AB | 0.2025 | 1 | 0.2025 | 39.55 | 0.1004 | |
| Residual | 0.0051 | 1 | 0.0051 | | | |
| Cor Total | 24.32 | 3 | | | | |

**Table 5:** Response 2: In-vitro drug release

| *Source* | *Sum of Squares* | *df* | *Mean Square* | *F-value* | *p-value* | |
|---|---|---|---|---|---|---|
| Model | 79.27 | 2 | 39.63 | 3301.46 | 0.0123 | significant |
| A-Almond oil | 74.23 | 1 | 74.23 | 6183.09 | 0.0081 | |
| B-Propylene glycol | 0.0000 | 0 | | | | |
| AB | 5.04 | 1 | 5.04 | 419.83 | 0.0310 | |
| Residual | 0.0120 | 1 | 0.0120 | | | |
| Cor Total | 79.28 | 3 | | | | |

**Table 6:** Drug content of nanoemulsion formulation

| S.NO | Formulation code | Drug content(%) ± SD |
|---|---|---|
| 1. | F1 | 96.72 ± 0.5 |
| 2. | F2 | 91.91 ± 0.7 |
| 3. | F3 | 95.62 ± 0.7 |
| 4 | F4 | 97.54 ± 0.2 |

*Scanning electron microscopy*

Scanning electron microscopy of nanoemulsion for the optimized formulation (F1) is shown in Figure 3. The shape of nanoemulsion was found to be spherical and the size of the nanoemulsion was below the µm range. Moreover, the micrograph also revealed some agglomeration of nanoemulsion which might be due to the evaporation of water present in formulation during sample preparation prior to SEM analysis (Figure 5).[24]

## Formulation and Evaluation of Nanoemulgel of Tolnaftate

*Determination of pH*

The pH of developed emulgel was shown in Table 5 and found to be 6.60.[25]

*Determination of spreadability*

The bioavailability and therapeutic property of the topical formulation depends upon the spreadability. The spreadability is expressed of time in seconds based on the slip-off from the gel by upper slide under certain load. The time taken to separate the two slides is less, indicating the topical formulation has better spreadability. Formulation F5 has this formulation's optimum viscosity and spreadability, which is 17.77 g.cm/sec. The spreadability value is shown in Table 6

*Measurement of viscosity*

The viscosity was calculated using brookfield viscometer with the spindle 63 for various rpm (10, 20, 30, 40 and 50) and the formulation values were shown in Table 7 to 10.

*Drug content ctudy*

The drug content of the formulation was shown in Table 11. The percentage drug content of a prepared nanoemulgel formulation was found to be 96.52%.[26]

*In-vitro drug release study*

Franz-diffusion cell method carried out in-vitro drug release for the developed nanoemulgel formulation. The release was found to be 70.42 ± 0.68% in 8 hours as shown in Figure 6 and Table 12.

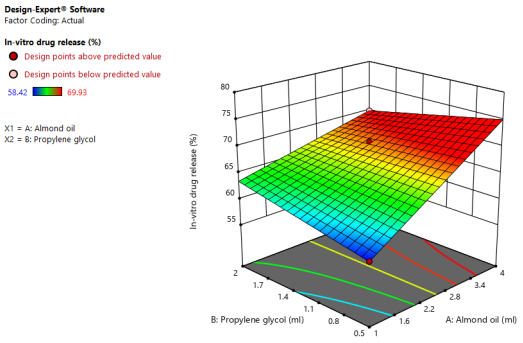


**Figure 3:** 3D graphical representation of *In-vitro* drug release

## SUMMARY

This research aimed to develop a novel nanoemulgel of tolnaftate for treating onychomycosis. An attempt has been made to develop a combination of two delivery systems i.e, nanoemulsions and emulgel as a nanoemulgel drug delivery system to overcome the problem associated with conventional therapy for the treatment of onychomycosis. UV Spectral analysis of tolnaftate at various phosphate buffer pH 7.4 concentrations showed linear results. Hence it obeyed Beer's Lambert law. Nanoemulsions of tolnaftate were prepared using a high-pressure homogenizer mixer. Four trial formulations were made by keeping drug (Tolnaftate), methylparaben, Tween 80, propylparaben, BHT (Butylated hydroxytoluene) as fixed ratio and varying the concentration of almond oil and propylene glycol using design of experiments (2 Level factorial design), obtained optimized formulation (F4) with significant an ANOVA with graphical representation. The developed Nanoemulsion formulation were characterized for drug content, SEM studies, *in-vitro* release study. Based on the *in-vitro* release studies, optimized formulation (F1) was converted into nanoemulgel formulation. *In-vitro* drug release study of all nanoemulsion formulation was carried out by diffusion method. Among all the developed formulation, the optimized formulation(F1) containing Almond oil and drug (Tolnaftate) showed sustained drug release of 58.42 ± 0.72 in 8 hours than other almond oil concentrations. The optimized formulation Fwas further developed into nanoemulgel gelling system by utilizing phase transition property of carbopol 940 polymers. Developed nanoemulgel formulation F5 was characterized for pH, viscosity, spreadability, drug content and *in- vitro* release study. pH was found to be 6.60 and it was found to be milky white dispersion. drug content was found

**Table 7:** *In-vitro* release profile of nanoemulsion formulation

| *Time* | *F1* | *F2* | *F3* | *F4* |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 15 | 8.25 ± 0.071 | 7.25 ± 0.51 | 6.15 ± 0.45 | 5.25 ± 0.017 |
| 30 | 15.22 ± 0.24 | 12.22 ± 0.22 | 10.22 ± 0.68 | 9.22 ± 0.42 |
| 45 | 18.11 ± 0.17 | 17.11 ± 0.19 | 14.11 ± 0.76 | 13.11 ± 0.71 |
| 1 | 22.23 ± 0.79 | 20.23 ± 0.65 | 18.23 ± 0.51 | 16.23 ± 0.97 |
| 1.30 | 28.49 ± 0.88 | 26.39 ± 0.78 | 22.49 ± 0.55 | 18.49 ± 0.88 |
| 2 | 30.41 ± 0.64 | 32.51 ± 0.44 | 26.41 ± 0.46 | 20.41 ± 0.46 |
| 2.30 | 32.24 ± 0.58 | 34.24 ± 0.76 | 28.24 ± 0.85 | 22.24 ± 0.85 |
| 3 | 34.52 ± 0.26 | 36.52 ± 0.67 | 32.52 ± 0.62 | 24.52 ± 0.62 |
| 3.30 | 36.19 ± 0.18 | 38.19 ± 0.22 | 36.19 ± 0.54 | 26.19 ± 0.81 |
| 4 | 38.25 ± 0.78 | 44.25 ± 0.56 | 40.25 ± 0.87 | 28.25 ± 0.87 |
| 4.30 | 40.19 ± 0.63 | 48.19 ± 0.54 | 44.19 ± 0.36 | 30.19 ± 0.36 |
| 5 | 42.52 ± 0.80 | 52.52 ± 0.65 | 48.52 ± 0.18 | 34.52 ± 0.80 |
| 5.30 | 44.72 ± 0.62 | 56.72 ± 0.34 | 50.72 ± 0.26 | 36.72 ± 0.26 |
| 6 | 46.66 ± 0.64 | 58.66 ± 0.87 | 52.66 ± 0.46 | 38.66 ± 0.46 |
| 6.30 | 48.40 ± 0.82 | 60.40 ± 0.24 | 56.40 ± 0.78 | 40.40 ± 0.28 |
| 7 | 50.12 ± 0.44 | 62.12 ± 0.82 | 58.12 ± 0.32 | 44.12 ± 0.44 |
| 7.30 | 54.66 ± 0.12 | 66.66 ± 0.35 | 62.66 ± 0.59 | 48.66 ± 0.21 |
| 8 | 58.42 ± 0.72 | 64.42 ± 0.76 | 68.42 ± 0.64 | 50.42 ± 0.27 |

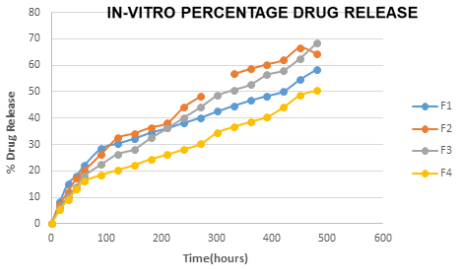


**Figure 4:** *In-vitro* percentage drug release of nanoemulsion formulation

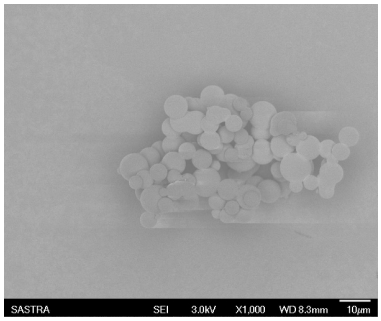


**Figure 5:** Scanning electron microscopy

**Table 8:** pH values of the formulations

| *formulation code* | *Observed pH (± SD)* |
|---|---|
| F5 | 6.60 ± 0.025 |

**Table 9:** Spreadability value of formulation.

| *S.no* | *Formulation Code* | *Spreadability(G.cm/Sec) ± S.d.* |
|---|---|---|
| 1. | F5 | 17.77 ± 0.025 |

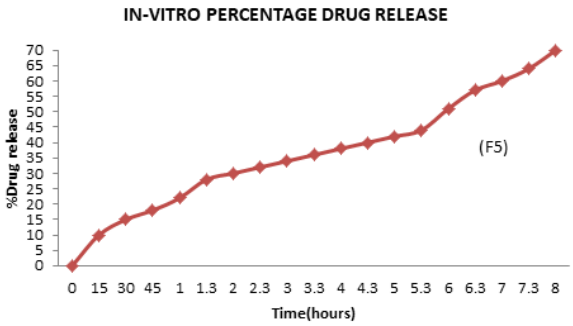


**Figure 6:** *In-vitro* percentage drug release of nanoemulgel formulation

**Table 10:** Viscosity values of the formulations

| *Rpm* | *Viscosity (Cp) at room temperature* |
|---|---|
| | F5 |
| 10 | 14960 |
| 20 | 14200 |
| 30 | 13050 |
| 40 | 13000 |
| 50 | 12350 |

**Table 11:** Drug content of the formulation

| *S. no* | *Formulation Code* | *Drug Content(%) ± Sd* |
|---|---|---|
| 1. | F5 | 96.52 ± 0.5 |

**Table 12:** *In-vitro* drug release of nanoemulgel

| Time | F5 |
|---|---|
| 0 | 0 |
| 15 | 10.25 ± 0.071 |
| 35 | 15.22 ± 0.42 |
| 45 | 18.11 ± 0.17 |
| 1 | 22.13 ± 0.87 |
| 1.30 | 28.49 ± 0.64 |
| 2 | 30.41 ± 0.56 |
| 2.30 | 32.24 ± 0.85 |
| 3 | 34.52 ± 0.62 |
| 3.30 | 36.19 ± 0.81 |
| 4 | 38.25 ± 0.76 |
| 4.30 | 40.19 ± 0.36 |
| 5 | 42.52 ± 0.72 |
| 5.30 | 44.72 ± 0.26 |
| 6 | 51.46 ± 0.67 |
| 6.30 | 57.40 ± 0.54 |
| 7 | 60.12 ± 0.48 |
| 7.30 | 64.66 ± 0.75 |
| 8 | 70.42 ± 0.68 |

to be 96%. The viscosity for the developed Nanoemulgel formulation was found to be satisfactory. *In-vitro* drug release study of nanoemulgel formulation was carried out by diffusion method. Among the developed formulation it showed sustained drug release of 70.42 ± 0.68 in 8 hours.[27]

## CONCLUSION

It is concluded that tolnaftate-loaded nanoemulsion is a viable alternative to conventional therapies by the way of providing sustained drug release, reducing the frequency of administration and more patient comfort. Therefore, the current study may provide an innovative approach and the developed tolnaftate nanoemulgel is a safe, effective and promising formulation for topical onychomycosis. Further, experimental and clinical studies are needed to confirm the results of the present study.

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