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FABRICATION AND CHARACTERIZATION OF CICLOPIROX OLAMINE LOADED NONIONIC SURFACTANT BASED NIOSOMES FOR TOPICAL DELIVERY

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Keywords:

Ciclopirox Olamine, Niosomes, Surfactant, Ether injection method, Film hydration method

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ABSTRACT: A number of strategies to deliver antifungal using nanocarriers are developed to facilitate drug targeting infected cells that result in improved antifungal activity. **Objective:** Ciclopirox olamine has a broad spectrum of action against dermatophytes, yeasts, filamentous fungi and bacteria. It has a biological half-life of 1.7 h and bioavailability of < 5% with prolonged use. A remarkable feature of the drug is that no single case of fungal resistance has been reported so far. Therefore, ciclopirox olamine loaded niosomes entrapped in suitable gel delivery systems may successfully deliver the drug for prolonged time in treatment of fungal infection. **Material and Method:** A Ciclopirox Olamine loaded niosomes were developed using various surfactants along with cholesterol in different proportions by ether injection and film hydration method. The prepared niosomes were evaluated for various characteristics such as shape and size, entrapment efficiency, *in-vitro* drug release studies. **Result and Discussion:** Among all, formulation CNFS61 showed optimal drug release with maximum entrapment efficiency having smaller vesicular size. So, formulation CNFS61 was considered as promising formulation and further characterized with respect to TEM, SEM, Zeta potential, Polydispersity index, vesicle properties and particle size diameter by Particle Sizer Analyzer (Malvern). **Conclusion:** It was concluded that the niosomal formulations of Ciclopirox Olamine can be successfully prepared by ether injection and film hydration method using different surfactants and also the results were revealed that all the formulation showed sustain drug release rate for 24 h.

INTRODUCTION: Topical application of drugs promises many advantages over oral or intravenous administration. It offers many advantages over conventional administration such as avoidance of first-pass metabolism and elimination of gastrointestinal irritation resulting in the improvement of patient convenience and compliance.

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However, the major barrier of the skin is the stratum corneum (SC), the top layer of the epidermis. Low molecular weight (≤500 Da), lipophilicity and effectiveness at low dosage are the ideal characteristics of the drugs for transdermal delivery. However, many drugs do not possess ideal physicochemical properties. Thus, manipulation of the drug or vehicle to enhance diffusion through skin becomes necessary [1].

Also, targeted drug delivery is designed for the localized effect of drug on the targeted site. Hence, surrounding tissues are not affected by the drug. Also, loss of drug does not happen due to localization of drugs, leading to getting maximum

efficacy of the medication. Different carriers have been used for targeting of drug, such as immunoglobulin, serum proteins, synthetic polymers, liposome, microspheres, erythrocytes and niosomes [2]. Niosomes occupy the general structure of bilayer vesicles, having a hydrophilic core shielded from one or multiple hydrophobic lipid bilayers. This unique structure enables them to both accommodate oil-soluble compounds as well as to encapsulate water-soluble drugs [3]. Moreover, surfactants contribute to the overall penetration enhancement of compounds primarily by adsorption at interfaces, by interacting with biological membranes and by alteration of the barrier function of the stratum corneum, as a result of reversible lipid modification [4]. Ciclopirox olamine (CPO), a broad-spectrum antifungal, is a hydroxypyridone derivative that has mechanism of action different from other marketed antifungal agents such as the azoles and the allylamines. It has a broad spectrum of action against dermatophytes, yeasts, filamentous fungi, and bacteria [5, 6]. Hence, in the present investigation, an attempt is made to develop and characterize niosomal formulation of Ciclopirox Olamine to treat fungal infections of the skin more efficiently.

MATERIALS AND METHODS: CPO was received as a gift sample from Kumar Organic Products Ltd., Bengaluru, Karnataka, India. All the other reagents were of analytical grade and were purchased from Sigma. Dialysis membrane-70 (2229.31 mm Avg. flat width) was purchased from HiMedia Laboratories Pvt. Ltd., Mumbai. All other chemicals were of analytical grade and procured from the authentic sources.

TABLE 1: FORMULATIONS OF CICLOPIROX OLAMINE NIOSOMES PREPARED BY ETHER INJECTION METHOD AND FILM HYDRATION METHOD

Method	Surfactant	Formulation Code	Ratio (Drug:Surfactant: Cholesterol)
Ether Injection Method	Span 40	$CNS4_1$	1:1:0.2
		$CNS4_2$	1:1.5:0.3
		$CNS4_3$	1:2:0.4
		$CNS4_4$	1:1:0.8
		$CNS4_5$	1:1:1
	Span 60	$CNS6_1$	1:1:0.2
		$CNS6_2$	1:1.5:0.3
		$CNS6_3$	1:2:0.4
		$CNS6_4$	1:1:0.8
		$CNS6_5$	1:1:1
	Tween 60	$CNT6_1$	1:1:0.2
		$CNT6_2$	1:1.5:0.3
		$CNT6_3$	1:2:0.4
		$CNT6_4$	1:1:0.8
		$CNT6_5$	1:1:1
Film Hydration Method	Span 40	$CNFS4_1$	1:1:0.2
		$CNFS4_2$	1:1.5:0.3
		$CNFS4_3$	1:2:0.4
		$CNFS4_4$	1:1:0.8
		$CNFS4_5$	1:1:1
	Span 60	$CNFS6_1$	1:1:0.2
		$CNFS6_2$	1:1.5:0.3
		$CNFS6_3$	1:2:0.4
		$CNFS6_4$	1:1:0.8
		$CNFS6_5$	1:1:1
	Tween 60	$CNFT6_1$	1:1:0.2
		$CNFT6_2$	1:1.5:0.3
		$CNFT6_3$	1:2:0.4
		$CNFT6_4$	1:1:0.8
		$CNFT6_5$	1:1:1

Preparation of Ciclopirox Olamine Loaded Niosomes by Ether Injection Method: Cholesterol and surfactant were dissolved in 5 ml of chloroform. Accurately weighed (100 mg) of Ciclopirox Olamine was dissolved in the above lipid solution. The resulting solution was slowly injected at a rate of 1 ml/ min into 20 ml of hydrating solution PBS pH 7.4. The solution was stirred continuously on a magnetic stirrer, and temperature was maintained at 55-65 °C.

As the lipid solution was injected slowly into the aqueous phase, the differences in temperature between phases cause rapid vaporization of chloroform, resulting in spontaneous vesiculation and formation of niosomes **Table 1** [7-9].

Preparation of Ciclopirox Olamine Loaded Niosomes by Thin Film Hydration Method: Surfactant, cholesterol, and drug were dissolved in 10 ml of chloroform. The lipid mixture was then transferred to a 100 ml round bottom flask, and the solvent was evaporated under reduced pressure at a temperature of 55-65 °C using a rotary evaporator till the formation of thin lipid film. The formed film was hydrated with 20 ml of PBS pH 7.4. The hydration was continued for 1 h, while the flask was kept rotating at 55-65 °C in the rotary evaporator. The hydrated niosomes were sonicated for 20 min using a bath sonicator to obtain niosomal dispersion containing both free and entrapped drugs of varying size **Table 1** [10-13].

Evaluation of Ciclopirox Olamine Niosomes:
Morphological Characterization:
Optical Microscopy: The vesicle formation was confirmed by optical microscopy in 45 X resolution. The niosome suspension placed over a glass slide and fixed over by drying at room temperature, the dry thin film of niosome suspension observed for the formation of vesicles [14-15].

Entrapment Efficiency: Entrapment efficiency of niosomes was determined by exhaustive dialysis method. The measured quantity of niosomal suspension was taken into a dialysis tube to which dialysis membrane was securely attached on one side. The dialysis tube was suspended in 100 ml PBS pH 7.4 containing 10% v/v methanol, which was stirred on a magnetic stirrer. The un-entrapped drug was separated from the niosomal suspension into the medium through the membrane.

At every hour entire medium (100 ml) was replaced with fresh medium (for about 6-7 h) till the absorbance reached a constant reading indicating no drug is available in the un-entrapped form. The withdrawn samples were checked for absorbance at 306.20 nm. The amount of entrapped drug was obtained by subtracting amount of un-entrapped drugs from the total drug incorporated [11, 12, 16].

Percent Entrapment = (Total Drug –Diffused Drug) / (Total Drug) × 100

Drug Content: Niosomes preparation equivalent to 1 mg of Ciclopirox Olamine (drug) was taken into a standard volumetric flask. Then they were lysed with 50% n-propanol by shaking. Then 1 ml of this was subsequently diluted with phosphate buffer saline (pH 7.4). The absorbance was measured at 306.20 nm and calculated drug content from the calibration curve [17-19].

***In-vitro* Drug Release Study:** The release of Ciclopirox Olamine from niosomal formulations was determined using membrane diffusion technique. The niosomes left after removal of un-entrapped drugs were dialyzed into a beaker containing 100 ml of PBS pH 7.4 containing 10% v/v methanol (to maintain sink condition), which acted as receptor compartment.

The temperature of the receptor medium was maintained at 37 ± 0.5 °C and agitated using magnetic stirrer. Aliquots of 5 ml sample were withdrawn periodically, and after each withdrawal same volume of medium was replaced. The collected samples were analyzed using UV spectrophotometer at 306.20 nm. The tests were carried out in triplicate [20-22].

Stability Studies: Optimized formulation was preserved at refrigerated temperature (4-8 ± 1°C) and room temperature (25 ± 2 °C) for 30 days. At the 30th day shape, percentage entrapment efficiency and percentage drug release of vesicles were measured. The results were compared with the initial shape, percentage entrapment efficiency and percentage drug release of both samples [23-24].

Evaluation of Promising Niosome Formulation (CNFS61): Particle size determinations (Particle size diameter, Polydispersity index (PDI) and Zeta potential): particle size diameter, polydispersity index, and zeta potential were determined at room temperature by Malvern Instruments. Niosomal formulations were diluted with phosphate-buffered saline, pH 7.4, for the vesicle diameter, polydispersity index, and zeta potential were determination respectively [15].

Transmission Electron Microscopy (TEM): The prepared niosomal formulation was characterized

for their morphology using transmission electron microscopy (TEM). Briefly, to an aliquot of a suspension of prepared niosomal formulation, a sufficient quantity of 1% phosphotungstic acid was added and mixed gently. A drop of the mixture was placed on to the carbon-coated grid and drained off the excess. The grid was allowed to dry and it was observed under TEM. Photographs were taken at suitable magnification.

Scanning Electron Microscopy (SEM): Shape and surface morphology of niosomes was studied using scanning electron microscopy (SEM). The niosomes formed were mounted on an aluminum stub with double-sided adhesive carbon tape. The vesicles were then sputter-coated with gold/ palladium using a vacuum evaporator and examined with the scanning electron microscope equipped with a digital camera.

RESULTS AND DISCUSSION: In the present research work, Ciclopirox Olamine was checked for compatibility of the drug with non-ionic surfactants and cholesterol by FT-IR study. Further, Ciclopirox Olamine niosomes were prepared using various non-ionic surfactants along with cholesterol in different proportions (1:0.2, 1.5:0.3, 2:0.4, 1:0.8 and 1:1) by ether injection and film hydration method. The prepared Ciclopirox Olamine niosomes were evaluated for various parameters such as shape, size analysis, entrapment efficiency, drug content, and *in-vitro* drug release study.

IR Study: The IR spectrum of the pure drug Ciclopirox Olamine displayed characteristic peaks at 3415.00 cm^{-1} for the O-H stretch, 2927.47 cm^{-1}, 2852.97 cm^{-1} peaks for C-H stretch, 1592.38 cm^{-1} for C=C stretch, 1634.31 cm^{-1} for C=O stretch, 1450.22 cm^{-1} for C-C stretch and 893.24 cm^{-1} for N-H wag. All the above characteristic peaks of the pure drug were also found in the IR spectrum of the formulations. Hence, there are no drug-excipients interactions.

Vesicles of Ciclopirox Olamine: Particle size analysis was carried out using an optical microscope with calibrated eyepiece micrometer. About 25 niosomes were measured individually, average was taken and mean diameter was calculated. The prepared vesicles were found to be spherical in shape **Table 2** and size was found to be less than 10.21 micrometer. The photographs reveal that the niosomes are spherical shape and no aggregation or agglomeration is observed **Fig. 4**. The size of niosomes prepared using span 60 by thin-film hydration method was found to be smaller when compared with the niosomes prepared using span 60 by ether injection method. The vesicles prepared with span 40 and Tween 60 by film hydration method and ether injection method were found to be higher as compared to vesicles prepared with span 60 by film hydration method and this is due to:

- The hydrophilic-lipophilic balance of tween 60 (14.9) and span 40 (6.7) is more than the span 60 (4.7), because the surface free energy decreases with an increase in hydrophobicity of surfactants.
- The film hydration method might be the result of partly uniform vesicle size and well-packed bimolecular film.
- With cholesterol concentration, the Span 60 tails gradually adopt a more conformation while the orientation.

The effect of surfactants and cholesterol on the size of niosomes was studied using different concentrations of surfactant: Cholesterol ratio. The results indicated that niosomal size decreased linearly with increasing cholesterol concentration and this is due to the decrease in surface energy with increasing hydrophobicity that results in smaller vesicles and also to the favorable interactions (hydrogen bonding or van der waal forces) between niosomal matrix and drugs. It was observed that the relative amount of surfactant and cholesterol was found to play an important role in the determination of vesicle size.

Vesicle size of drug-loaded niosomal batches was found to decrease as concentration of surfactant and cholesterol increases. This may be due to hydrophobic Ciclopirox Olamine intercalate into the lipid bilayer leading to appreciable cohesion among a polar portion of the membrane, causing reduction in the vesicle size. Results indicate that vesicle sizes are dependent on both the method of vesicle preparation, the composition of the bilayer, and drug-loaded.

Entrapment Efficiency: The entrapment efficiency of the prepared Ciclopirox Olamine niosomes was measured by the dialysis method. The entrapment efficiency was determined by subtracting the amount of drug dialyzed from the total amount of drug in the formulation. In all the prepared formulations, the impact of cholesterol, surfactant, and method of preparation on entrapment efficiency was significant. The results of entrapment efficiency were shown in table **Table 2**. In the present study, the observed percentage entrapment efficiency for all the formulations was in the range of 53.12 ± 1.21 to 83.54 ± 1.98%. Among all the formulations, formulation CNT63 (83.54 ± 1.98%) showed maximum entrapment efficiency.

The entrapment efficiency decreased in the order of Span 40 < Span 60 < Tween 60. The percent entrapment efficiency of Ciclopirox Olamine niosomes by film hydration method exhibited a lower value than that prepared by ether injection method. The difference in % entrapment efficiency may be due to the greater encapsulated volume in unilamellar vesicles of ether injection method than multilamellar vesicle structure of film hydration method. The entrapment efficiency of tween 60 was found to be more than Span 40 and Span 60 because of entrapment efficiency decreases with decrease in HLB value.

The incorporation of cholesterol (CHO) is known to influence vesicle stability and permeability. The addition of cholesterol (CHO) to the surfactant was required to form stable nonionic surfactant based vesicles. CHO almost always present in lipid vesicles as well as biomembranes and influences a number of membrane properties such as ion permeability, aggregation, fusion process, elasticity, size, and shape.

Being amphipathic, CHO can insert itself into the bilayer membrane with its hydrophilic head oriented towards the aqueous surface and aliphatic chain line up parallel to the hydrocarbon chains in the center of the bilayer. It is known that CHO increases the chain order of the liquid-state bilayer and strengthens the non-polar tail of the nonionic surfactant. An increase in cholesterol concentration, leads to an increase in the entrapment levels of Ciclopirox Olamine up to a certain extent.

***In-vitro* Release Studies:** The *in-vitro* release profile of Ciclopirox Olamine the formulations was determined in PHS (pH 7.4) for period of 24 h. The percent cumulative drug release after 24 h from different formulations was found to be in the range of 42.77 ± 1.29 to 70.65 ± 2.14%. Among all, the formulations prepared by thin-film hydration method showed maximum drug release as compared to ether injection method in 24 h. The order of percentage drug release in 24th hour was Span 40 > Span 60 > Tween 60. In all the prepared formulations, the impact of cholesterol and surfactant concentration on release profile was observed.

The increase of cholesterol content resulted in a reduction of membrane permeability, which leads to lower drug elution from the vesicles. All the niosomal formulations release profiles were subjected to various kinetic equations like first-order plots, Higuchi diffusion plots, and Peppas log-log plots. The regression coefficient values of these kinetic equations are very nearer to one, suggesting that plots are fairly linear. Slope values of peppas log-log plots are between 0.698 to 0.796 suggesting that the drug release by non-fickian release mechanism *i.e.,* the drug were released by combination of both diffusion and erosion controlled drug release.

Among all the 30 formulations, formulation CNFS61 showed optimal drug release with maximum entrapment efficiency having smaller vesicular size. So, after considering all these parameters, formulation CNFS61 was considered as promising formulation. So, formulation CNFS61 was further characterized with respect to Transmission electron microscopy (TEM), Scanning Electron Microscopy (SEM), Zeta potential, Polydispersity index (PDI), vesicle properties and particle size diameter by Particle Sizer analyzer (Malvern).

Particle Size and Zeta Potential Determination: Z-Average particle size diameter and polydispersity index, were determined at room temperature by Zeta Potential/Particle Sizer analyzer (Malvern Instrument). The average particle size diameter and polydispersity index of the freshly prepared Ciclopirox olamine niosomal formulation (CNFS61) are shown in **Fig. 1** and **Fig. 2** respectively. The

average particle size diameter was found to be 505 nm. These results were in good agreement with the particle size of niosomes prepared by using span 60 as a surfactant. The calculated polydispersity index of CNFS61 niosomal formulation was found to be 0.191. A polydispersity index of 1 indicates large variations in particle size; a reported value of 0 means that size variation is absent. The obtained low values of polydispersity index of the prepared niosomes indicate a limited variation in particle size. The zeta potential of the CNFS61 formulation was carried out by using Zeta Potential analyzer (Malvern) at room temperature by diluting the formulation with phosphate-buffered saline, pH 7.4. The zeta potential of CNFS61 formulation was -40.1 mV represents high stability of formulation **Fig. 3**.

TABLE 2: EVALUATION PARAMETERS OF THE CICLOPIROX OLAMINE NIOSOMES

S. no.	Formulation Code	Particle size* ± SD (µm)	Shape of the vesicles	Percentage Entrapment Efficiency*± SD	Drug Content*± SD	% drug release at 24 h
1	$CNS4_1$	9.21 ± 1.90	Spherical	55.23 ± 1.34	98.35 ± 0.87	65.213 ± 0.253
2	$CNS4_2$	9.08 ± 2.11	Spherical	60.12 ± 0.67	97.88 ± 1.89	61.231 ± 0.622
3	$CNS4_3$	8.89 ± 2.41	Spherical	65.98 ± 1.09	99.01 ± 0.76	57.243 ± 1.274
4	$CNS4_4$	7.24 ± 2.58	Spherical	62.34 ± 0.89	97.67 ± 0.34	63.112 ± 0.187
5	$CNS4_5$	7.02 ± 1.18	Spherical	64.19 ± .56	98.04 ± 0.67	60.078 ± 0.276
6	$CNS6_1$	8.81 ± 1.82	Spherical	71.45 ± 0.44	99.06 ± 1.25	55.345 ± 1.009
7	$CNS6_2$	8.65 ± 2.38	Spherical	74.21 ± 1.54	98.67 ± 1.01	49.163 ± 0.282
8	$CNS6_3$	8.04 ± 2.42	Spherical	79.06 ± 1.02	97.45 ± 0.76	44.278 ± 1.192
9	$CNS6_4$	7.09 ± 1.28	Spherical	73.23 ± 0.87	97.88 ± 0.72	52.876 ± 0.276
10	$CNS6_5$	6.36 ± 1.23	Spherical	76.34 ± 0.06	98.15 ± 0.39	46.845 ± 1.229
11	$CNT6_1$	10.09 ± 1.24	Spherical	75.25 ± 0.14	99.15 ± 0.14	48.781 ± 2.14
12	$CNT6_2$	10.01 ± 1.56	Spherical	78.21 ± 1.20	97.25 ± 1.24	45.214 ± 2.987
13	$CNT6_3$	9.88 ± 2.16	Spherical	83.54 ± 1.98	98.12 ± 1.21	42.771 ± 1.291
14	$CNT6_4$	9.02 ± 1.01	Spherical	77.01 ± 0.24	98.14 ± 2.54	47.427 ± 0.014
15	$CNT6_5$	8.36 ± 2.17	Spherical	80.12 ± 1.54	99.01 ± 1.45	43.242 ± 2.141
16	$CNFS4_1$	9.89 ± 2.14	Spherical	53.12 ± 1.21	98.12 ± 2.15	70.65 ± 2.14
17	$CNFS4_2$	9.58 ± 3.14	Spherical	56.73 ± 2.01	98.78 ± 3.65	67.05 ± 2.78
18	$CNFS4_3$	9.23 ± 1.48	Spherical	60.16 ± 1.88	97.01 ± 1.84	63.57 ± 3.78
19	$CNFS4_4$	7.90 ± 4.11	Spherical	54.33 ± 1.65	99.77 ± 1.45	67.15 ± 1.97
20	$CNFS4_5$	7.62 ± 2.74	Spherical	59.03 ± 1.49	97.14 ± 2.87	64.87 ± 1.58
21	$CNFS6_1$	5.98 ± 1.24	Spherical	70.49 ± 2.15	98.16 ± 1.52	67.28 ± 1.85
22	$CNFS6_2$	5.82 ± 0.59	Spherical	73.27 ± 1.45	99.42 ± 1.88	62.58 ± 2.14
23	$CNFS6_3$	5.36 ± 2.16	Spherical	77.17 ± 1.01	97.48 ± 2.01	59.12 ± 3.02
24	$CNFS6_4$	5.13 ± 164	Spherical	71.33 ± 2.14	99.54 ± 1.47	63.31 ± 3.49
25	$CNFS6_5$	5.01 ± 1.84	Spherical	75.83 ± 0.84	97.78 ± 2.11	60.73 ± 3.28
26	$CNFT6_1$	10.21 ± 2.25	Spherical	72.25 ± 1.26	98.24 ± 2.02	53.88 ± 1.220
27	$CNFT6_2$	10.13 ± 1.56	Spherical	75.71 ± 2.12	97.01 ± 1.29	49.11 ± 2.100
28	$CNFT6_3$	10.00 ± 1.28	Spherical	78.11 ± 0.98	98.05 ± 1.85	45.67 ± 1.230
29	$CNFT6_4$	9.14 ± 2.11	Spherical	74.81 ± 1.26	98.09 ± 2.47	49.92 ± 1.750
30	$CNFT6_5$	8.50 ± 1.22	Spherical	78.02 ± 1.84	97.58 ± 1.05	46.34 ± 2.450

*Values represented as mean ± SD

Particle Size:

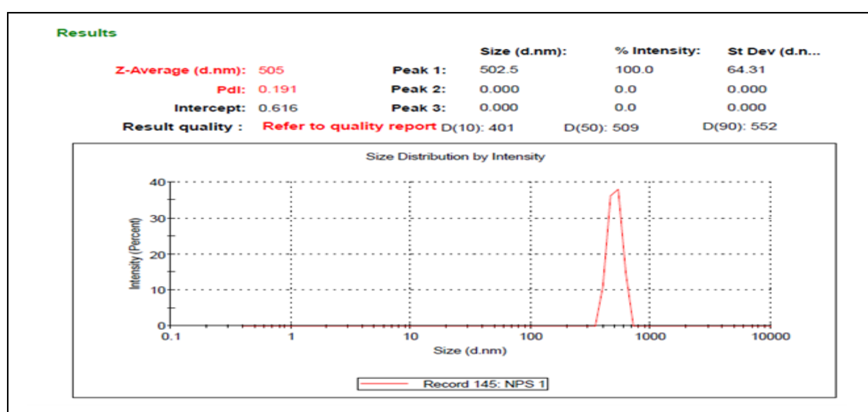

FIG. 1: PARTICLE SIZE PEAK OF NIOSOMAL FORMULATION (CNFS61)

Particle Distribution Size of Niosomal Formulation (Polydispersity Index):

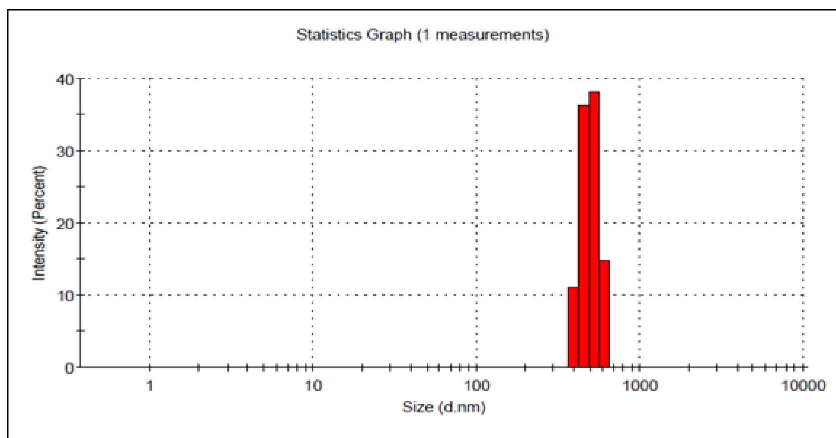

FIG. 2: PARTICLE DISTRIBUTION SIZE OF NIOSOMAL FORMULATION (CNFS61)

Zeta Potential:

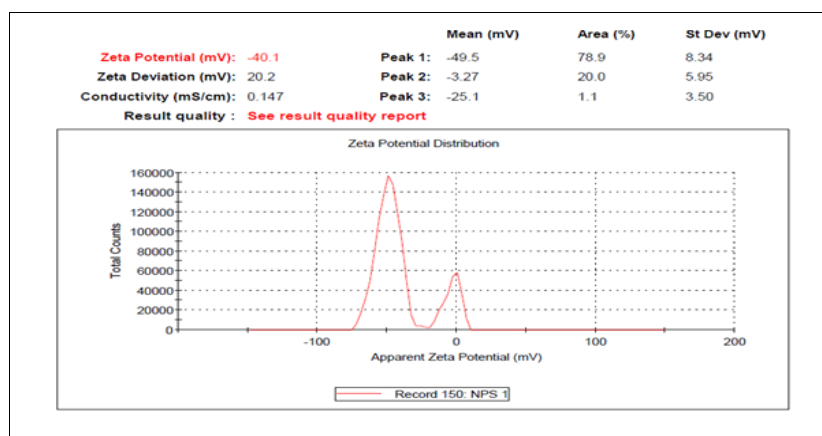

FIG. 3: ZETA POTENTIAL GRAPH OF NIOSOMAL FORMULATION (CNFS61)

Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM): Photographs **Fig. 4** taken with a microscope at 45x magnification gives the idea of shape and size attained by the vesicles. The prepared niosomal formulation (CNFS61) was characterized by morphology using SEM and TEM. The primary difference in data output between the two techniques is the way in which the nanoparticle images are resolved. SEM produces accurate 3D images of particles in the dispersion while TEM produces 2D images that require further interpretation. TEM systems are capable of delivering much greater resolution.

TEM also derives internal composition details, such as a particle's crystallinity and lattice structure. SEM also provides this information but is well suited to looking at samples' surface characteristics. A scanning electron micrograph is taken to illustrate the vesicle formation, vesicle diameter and surface characteristics of drug-loaded niosomes. SEM and TEM revealed that niosomes were spherical in shape. SEM of formulation CNFS61 showed the smooth surface of niosomes formed.

Some unevenness of vesicles that observed under the study may be due to the drying process under normal environment conditions **Fig. 6**. TEM microphotographs gave sub nanometer resolution of the observed CNFS61 formulation. Niosomal vesicles appeared as spherical and lamellar under TEM **Fig. 5**. It also revealed the presence of spherical niosomes showing gradual increase in transparency from the center to the periphery but some other vesicles appeared as dark spherical spots that exist in disperse and aggregate collections, including the presence of pores and minor surface roughness.

Ciclopirox Olamine niosomes were successfully developed as a carrier for site-specific drug delivery by ether injection and thin-film hydration technique using the drug, surfactants, and cholesterol. The formulation (CNFS61) containing surfactant Span 60 showed good drug content as of 98.16 ± 1.52%, better entrapment efficiency as of 70.49 ± 2.15% with optimum drug release that is 67.28 ± 1.85%, minimal mean vesicular diameter as of 505 nm and zeta potential as of -40.1 mV. Hence, Span 60 was used as a good surfactant to form niosomes and thin-film hydration technique was an optimized technique for the preparation of Ciclopirox Olamine niosomes.

Optical Microscopy:

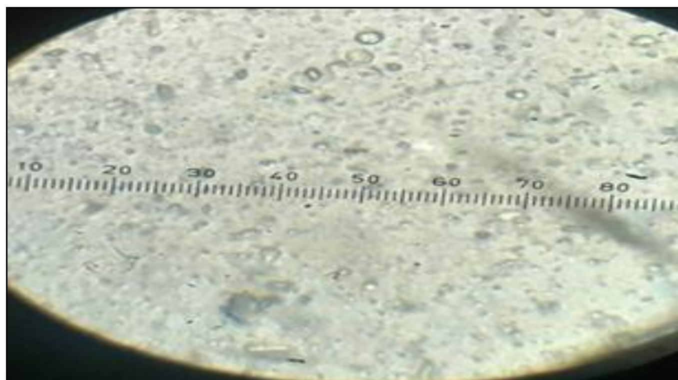

FIG. 4: OPTICAL MICROSCOPY OF NIOSOMES AT 45X MAGNIFICATION (CNFS61)

Transmission Electron Microscopy (TEM):

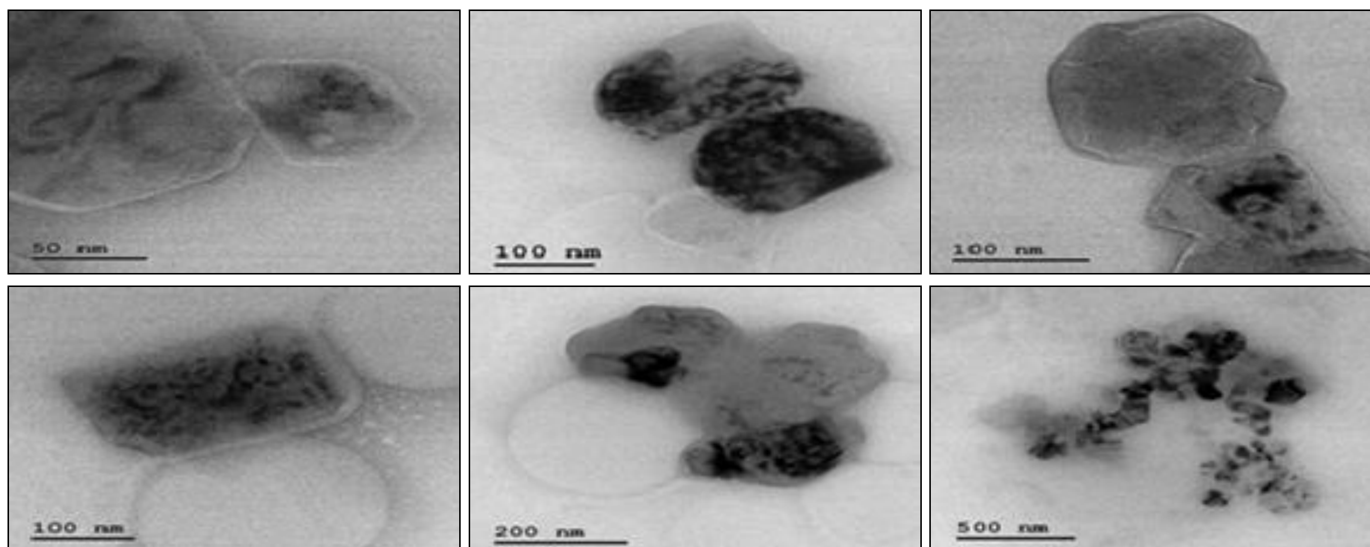

FIG. 5: TRANSMISSION ELECTRON MICROSCOPY PHOTOGRAPHS OF NIOSOME FORMULATION (CNFS61)

Scanning Electron Microscopy (SEM):

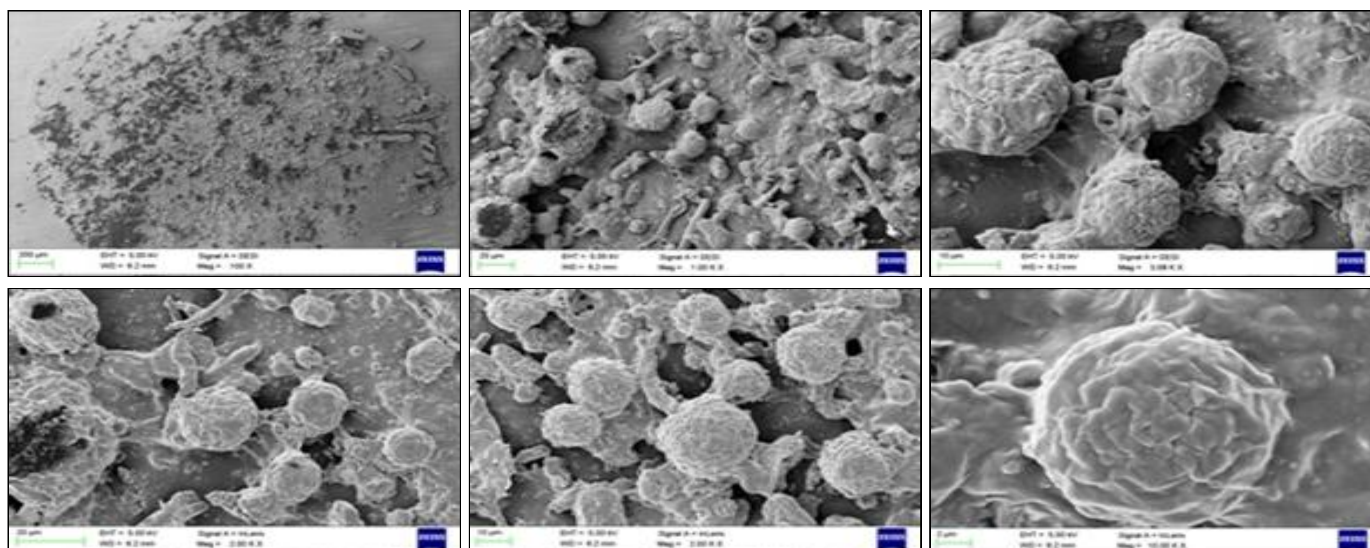

FIG. 6: SCANNING ELECTRON MICROSCOPY PHOTOGRAPHS OF NIOSOME FORMULATION (CNFS61)

CONCLUSION: In the present investigation, it was concluded that the niosomal formulations of Ciclopirox Olamine can be successfully prepared by ether injection and film hydration method using different surfactants such as Span 40, Span 60 and Tween 60 as non-oinic surfactant along with cholesterol. This study also indicated that all the prepared formulations showed sustain drug release rate for 24 h out of all thirty formulations. The formulation (CNFS61) containing surfactant Span 60 showed good drug content as of 98.16 ± 1.52%, better entrapment efficiency as of 70.49 ± 2.15% with optimum drug release that is 67.28 ± 1.85%, minimal mean vesicular diameter as of 505 nm and zeta potential as of -40.1 mV.

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