IJBPAS, December, 2026, 15(12): 6234-6250

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

LECIPLEX: NOVEL TOPICAL ANTIFUNGAL FORMULATION & EVALUATION

ADSUL S*, KASHID P, MANDHARE T AND OTARI K

Department of Pharmaceutics, Navsahyadri Institute of Pharmacy, DBATU University, Lonere, Pune- 412213, Maharashtra, India

***Corresponding Author: Dr. Adsul S: E Mail:** sakshiadsul91@gmail.com

Received 25th June 2026; Revised 28th July 2026; Accepted 12th Oct. 2026; Available online 1st Dec. 2026

https://doi.org/10.31032/IJBPAS/2026/15.12.10730

ABSTRACT

Fungal infections continue to pose a major global health burden due to their chronic nature, high recurrence rates, and the emergence of resistant strains. Conventional antifungal therapies often suffer from limited bioavailability, poor penetration, and undesirable side effects, highlighting the need for innovative delivery approaches. In this study, novel cationic nanocarriers known as LeciPlex were developed and evaluated for the delivery of antifungal agents. The system was prepared by using soy phosphatidylcholine in combination with cationic surfactants through a simple one-step fabrication method. Preformulation studies, analytical method development by UV spectroscopy, and optimization of formulation parameters were carried out to ensure stability and reproducibility. The optimized batches were rigorously characterized by evaluating their particle size, viscosity, entrapment efficiency and in-vitro release kinetics. Antifungal efficacy was assessed through zone of inhibition studies, while safety was confirmed using histopathological and HET-CAM tests. Results demonstrated that the LeciPlex system enhanced drug entrapment, improved stability, and provided sustained release with significant antifungal activity compared to conventional formulations. These findings suggest that LeciPlex offers a promising platform for the effective and safe delivery of antifungal drugs, with potential for further clinical translation.

Keywords: Fungal infection, Global health burden, Resistant strain, Antifungal therapy, Drug delivery

INTRODUCTION

Globally, fungal infections constitute a major public health challenge, impacting the lives of millions each year. Despite advancements in medical science, the emergence of drug-resistant fungal strains and limitations of existing antifungal therapies necessitate

continuous research and innovation in the field of antifungal drug delivery systems **[1]**.

Leciplex:

Lecithin, a fundamental component of cellular membranes, has long been employed in drug delivery research due to its excellent biocompatibility. Its ability to interact with both hydrophobic and hydrophilic drugs makes it particularly valuable in design of liposomes and other lecithin-based nanocarriers. Phospholipids, being natural constituents of cell membranes, are inherently biocompatible and thus suitable for incorporation into drug delivery systems. Example of cationic surfactants includes cetyltrimethylammonium bromide (CTAB) and didodecyl dimethyl ammonium bromide (DDAB) serve as stabilizers and solubilizers for nanoparticles. Evidence suggests that cationic formulations offer slight advantages over neutral ones, particularly in enhancing drug release and cellular uptake. By combining benefits of lecithin and cationic surfactants, researchers have developed self-assembled phospholipid-based cationic nanocarriers using biocompatible solvents. By utilizing a straightforward, single-step assembly method, these vesicular systems are constructed from cationic surfactant and negatively charged phospholipids. Their positively charged surface facilitates electrostatic interactions with negatively charged mucin, thereby improving ocular bioavailability **[3]**.

Leciplex utilizes a one-step fabrication method, deriving its superior thermodynamic stability from the exploitation of charged molecular interactions. In this approach, type of anti-solvent or solvent dispersion method was employed. The procedure began by dissolving both the phospholipids and the necessary charge-imparting component into a biocompatible solvent namely Transcutol HP. The organic phase was heated to exceed the lipid phase transition temperature before being hydrated with an aqueous medium maintained at the same thermal condition. This process yielded a stable dispersion of self-assembled vesicles within manometer size range.

Method of Preparation:

Lecithin based Cationic Nanoparticles are prepared by simple one step fabrication process in this lecithin and cationic surfactant are used in different molar concentration. Both are dissolved in biocompatible and biodegradable solvents (2 pyrrolidone, diethylene glycol monoethyl ether, etc.) by constant heating at 70˚C on water bath. To this oil phase, double distilled water maintained at same temperature as of oil phase is poured directly with cyclomixing at 1200 rpm.

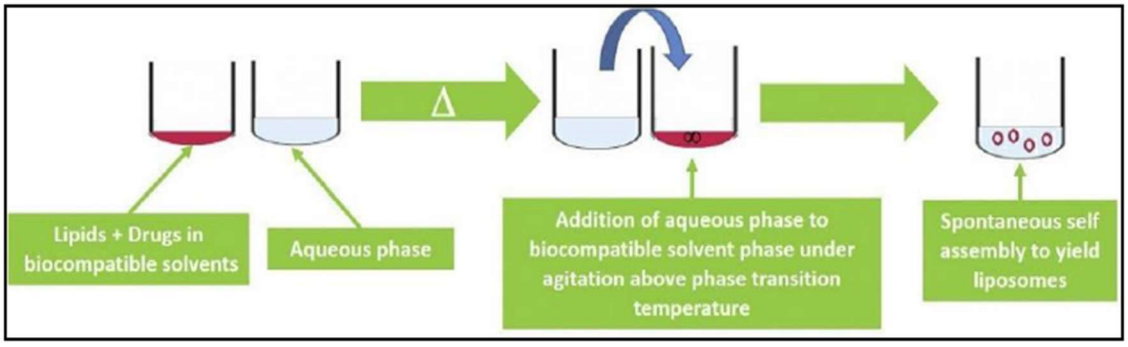


Fig 1: Schematic representation of Leciplex

MATERIALS AND METHODS:

Materials

Luliconazole and Posoconazole were purchased from Metrochem API Pvt, Ltd, India **[5, 6]**. SPC Lipoid GmBH, Germany **[7]**. DDAB Tokyo Chemical Industry Co. Ltd, Japan **[21]**. TranscutolP Gattefosse India Ltd, Mumbai.

Methods

Preformulation:

Identification Characterization:

Determination of Organoleptic evaluation of drug:

1. Colour: A small amount was spread over butter paper and conducting a visual inspection under adequate lighting.

2. Odour: A small sample of the substance was cautiously evaluated to determine its characteristics odour.

3. Determination of Melting point: The drug's melting point was determined using the capillary method. A sample was packed into a capillary tube sealed at one end and subsequently immersed in a liquid paraffin bath within the melting point apparatus. The temperature at which the sample transitioned from a solid to a liquid state was then recorded **[11]**.

Fourier transform infrared (FT-IR) spectroscopy: Fourier transform Infrared (FT-IR) spectroscopy serves as a highly adaptable analytical tool for characterizing materials within the carbon-based family. The KBr disc method was used to get the IR absorption spectrum of luliconazole in the range 400-4000 cm^{-1} using an IR spectrophotometer. FTIR spectroscopy investigations used to determine the compatibility of drug (Luliconazole & Posoconazole) and excipients **[17]**.

Analytical method development by using UV spectroscopy:

Development of calibration curve: To establish the λ_{max} of Luliconazole, a 10 mg sample was precisely weighed and subsequently dissolved in 10 ml of methanol

& for Posoconazole instead of methanol, Dichloromethane used as solvent to make concentration 1000µg/ml. From this 1ml was taken and diluted upto10ml, also from this 1ml was taken and diluted by using methanol and in phosphate buffer solution pH 5.5 to prepare 10µg/ml, respectively. The UV spectrum of the sample was recorded over the wavelength range 200-400nm **[12]**.

Formulation and Development of optimized Leciplex:

Table 1: Formulation of Optimized Luliconazole and Posoconazole Leciplex

Ingredients	Quantity	Manufacturer/ Supplier
Luliconazole	25mg	Metrochem API Pvt Ltd
SPC	186mg	Lipoid GmBH, Germany
DDAB	111mg	Tokyo Chemical Industry Co. Ltd, Japan
TranscutolP	0.5ml	Gattefosse India Ltd, Mumbai
Water	9.5ml	In-house laboratory preparation

Ingredients	Quantity	Manufacturer/ Supplier
Posoconazole	25mg	Metrochem API Pvt Ltd
SPC	186mg	Lipoid GmBH, Germany
DDAB	111mg	Tokyo Chemical Industry Co. Ltd, Japan
TranscutolP	0.5ml	Gattefosse India Ltd, Mumbai
Water	9.5ml	In-house laboratory preparation

Evaluation of Optimized batch:

Determination of Particle size: Particle size and polydispersity were evaluated via photon correlation spectroscopy using a Nanophox system (Sympatech, Germany) at ambient temperature. To prevent multi-scattering interference, each batch was diluted 100-fold with filtered, double-distilled water until an optimal concentration was reached. Samples were introduced into the dispersion unit under gentle agitation to mitigate inter-particle interactions and potential aggregation. Ultimately, the formulation demonstrating the smallest particle size coupled with optimal stability was selected for subsequent studies.

Entrapment efficiency: Entrapment efficiency is the percent concentration of incorporated active ingredients detected in formulation over the initial concentration. NaCl was added to one millilitre. To isolate the nanoparticles, the dispersion was centrifuged at 14,000 rpm for 30 minutes, with the addition of NaCl to promote separation. Following centrifugation, the supernatant was collected and analyzed via spectrophotometry at 295 nm. The concentration of the encapsulated drug was then determined by referencing a standard calibration curve. The % entrapment efficiency was calculated using following equation:

$$\text{Entrapment efficiency (weight \%)} = \frac{T-C}{T} \times 100$$

Where T represents the total quantity of Luliconazole (LCZ) incorporated during the nanoparticles preparation, and C denotes the concentration of free LCZ detected within the supernatant.

Stability study: The stability of the formulation must be a crucial factor in deciding whether they should be accepted or rejected. Trial batches were exposed to normal temperature and humidity conditions during stability experiments to see if they render precipitation or not.

Determination of pH: The pH of the formulation was assessed using a calibrated digital pH meter. A 0.5 g sample of the Luliconazole/Posoconazole-loaded leciplex gel was dispersed uniformly in distilled water, after which the pH of the resulting mixture was determined. Every measurement was conducted in triplicate to ensure reproducibility, and the final values are reported as averages.

Determination of viscosity: The viscosity of the developed gel formulations was evaluated at room temperature using a Brookfield DV-II+ Pro viscometer (Mumbai, Maharashtra, India) equipped with a number 91 spindle. The sample holder was filled with the gel, followed by the insertion of the spindle. Rheological measurements were then conducted at a constant rotation speed of 100 rpm.

Zone of Inhibition: Weigh the peptone2gm meat extract0.3gm sodium chloride 0.5gm in 100ml water in 3 conical flasks. Dissolve all ingredients in distilled water in conical flask, plug cotton & cover with paper and autoclave it. Autoclave culture media at 15 psi or 121 °C for 15 minutes. Then make agar media for growing the E- Coli culture by using spreading technique. The antimicrobial efficacy of the test substance is evaluated by placing it in the center of a seeded agar plate. For liquid formulations, a well is bored into the agar to accommodate the sample. The plates are then incubated for 18–24 hours (or as required) at an optimal temperature for the specific microorganism. Antimicrobial activity is indicated by a clear 'zone of inhibition' surrounding the sample, caused by the diffusion of the active agent into the agar, which suppresses microbial growth. Generally, the diameter of this zone is directly proportional to the potency of the antimicrobial agent.

Histopathology Study: Goat eyeballs were enucleated and preserved in 10% formalin. Following preservation, the cornea was isolated, rinsed, and prepared for ex-vivo study. The tissue was dehydrated through a series of graded alcohol concentrations,

cleared in xylene, and embedded in paraffin wax. Tissue sections were prepared at a thickness of 4–6 \mum. These sections were subsequently deparaffinized in xylene and stained with hematoxylin and eosin (H&E) to facilitate histopathological assessment via light microscopy **[22]**.

HET-CAM test: The Hen's Egg-Chorioallantoic Membrane (HET-CAM) assay is a recognized alternative method for evaluating the irritation potential of substances. In this procedure, incubated chicken eggs are carefully opened on the ninth day of development to expose the chorioallantoic membrane (CAM). The study involves three groups: a negative control treated with 0.9% NaCl, a positive control treated with 0.1 N NaOH, and a test group subjected to the leciplex formulation. The membrane's response to each substance is monitored over time to determine its comparative irritation potential.

RESULTS

Preformulation:

Organoleptic characteristics:

Table 2: Organoleptic characteristics

- **Colour:**

Drug	Standard	Observed
Luliconazole	White	White
Posoconazole	White	White

- **Odour:**

Drug	Standard	Observed
Luliconazole	Odourless	Odourless
Posoconazole	Odourless	Odourless

- **Melting Point**

Drug	Standard	Observed
Luliconazole	150-154°C	151-152°C
Posoconazole	170-172°C	174-176°C

FT-IR Spectroscopy:

FTIR of Luliconazole: The IR spectrum of Luliconazole was recorded by using FTIR spectrometer. The FTIR spectrum exhibited characteristic absorption bands identical to the reported IR frequencies of luliconazole, thereby confirming its identity and purity. IR spectra and characteristic functional groups were observed in FTIR spectrum as shown in **Table 3** frequencies of Luliconazole functional group:

Table 3: IR frequencies of Luliconazole functional group

Functional group	Reported IR frequencies	Observed IR frequencies
C-H Ar Stretching	3150-3050	3070.4
C-H Ali Stretching	3000-2850	2989.12
S-H Stretching	2600-2550	2570.6
C=N Alk Stretching	2260-2240	2239.9
C=C Alk Stretching	1680-1600	1653.6
C=N Stretching	1690-1640	1648.8

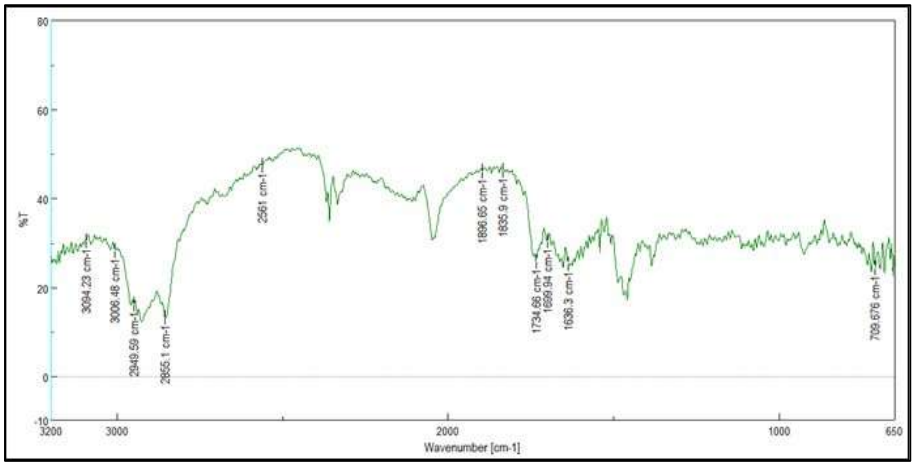


Fig 2: FTIR spectrum of Luliconazole

FTIR of Posoconazole: The IR spectrum of Posoconazole was recorded by using FTIR spectrometer. The FTIR spectrum exhibited characteristic absorption bands identical to the reported IR frequencies of luliconazole, thereby confirming its identity and purity. IR spectra and characteristic functional groups were observed in FTIR spectrum as shown in **Table 4** frequencies of Posoconazole functional group:

Table 4: IR frequencies of Posoconazole functional group

Functional group	Reported IR frequencies	Observed IR frequencies
O-H Stretching	3400-3200	3318
C-H Alk Stretching	3000-2850	2862
C=O Stretching	1725-1705	1735
C-H Ar Stretching	3150-3050	3092
C-O-C Ar Stretching	1250-1050	1190
C-H benzene and triazole Stretching	900-690	825

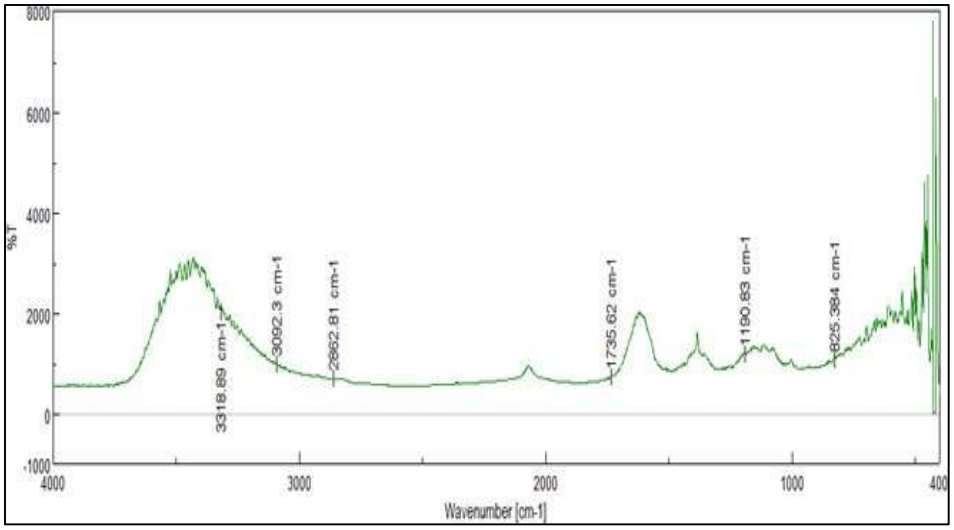


Fig. 3: FTIR spectrum of Posoconazole

Analytical method development and validation by UV spectroscopy Estimation of λmax:

A stock solution with a concentration of 100 µg/ml was prepared by accurately weighing 10 mg of Luliconazole and dissolving it in methanol to a final volume of 100 ml. Subsequently, a 1 ml aliquot of this stock was withdrawn and diluted with methanol to a total volume of 10 ml to achieve the desired analytical concentration. UV spectrum was recorded from 400-200 nm. The λmax of drug was found to be 295.4nm in methanol **Fig. 4** and 295.4 nm in phosphate buffer solution maintained at pH 5.5.

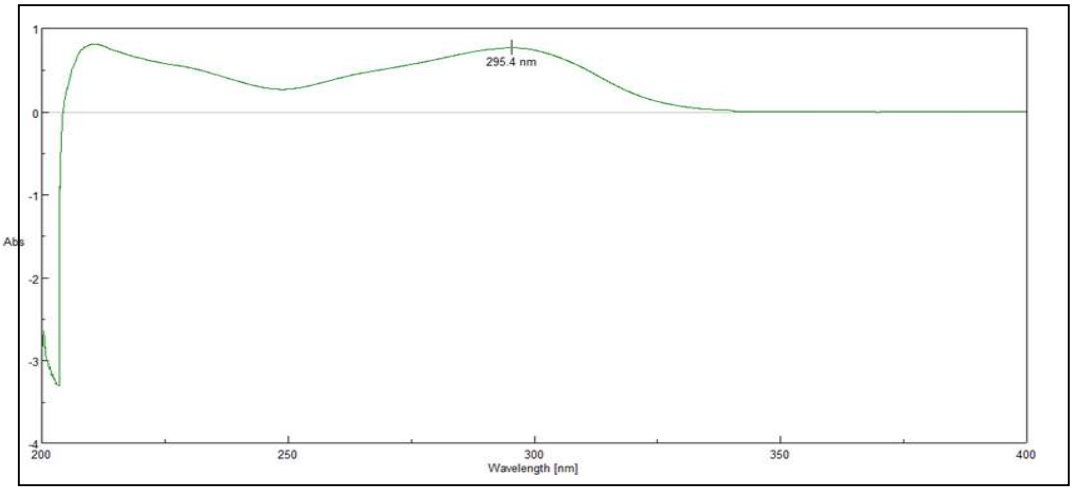


Fig 4: λ max of Luliconazole in methanol

The overlay of Luliconazole was performed to check the fixed wavelength of the drug at different concentrations. The overlay spectra displayed the five distinct concentration levels 1.2, 2.4, 3.6, 4.8, and 6.0 µg/ml all consistently exhibiting maximum absorbance at a wavelength of 295.4 nm.

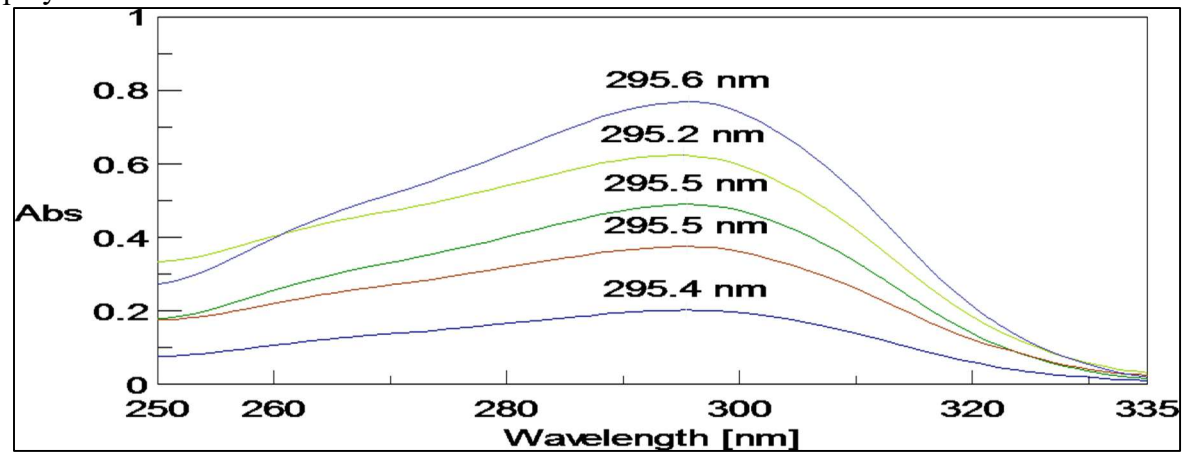


Fig. 5: Overlay of Luliconazole

Calibration curve of Luliconazole in methanol: A linear relationship was obtained in Beer-Lambert's plot of Luliconazole ($y=0.0713x+0.066$ $R^2=0.997$) shown in **Table 5**.

Table 5: Concentration and its Absorbance in Methanol

Concentration (µg/ml)	Absorbance
0	0
2	0.1838
4	0.3485
6	0.5007
8	0.6535
10	0.8038

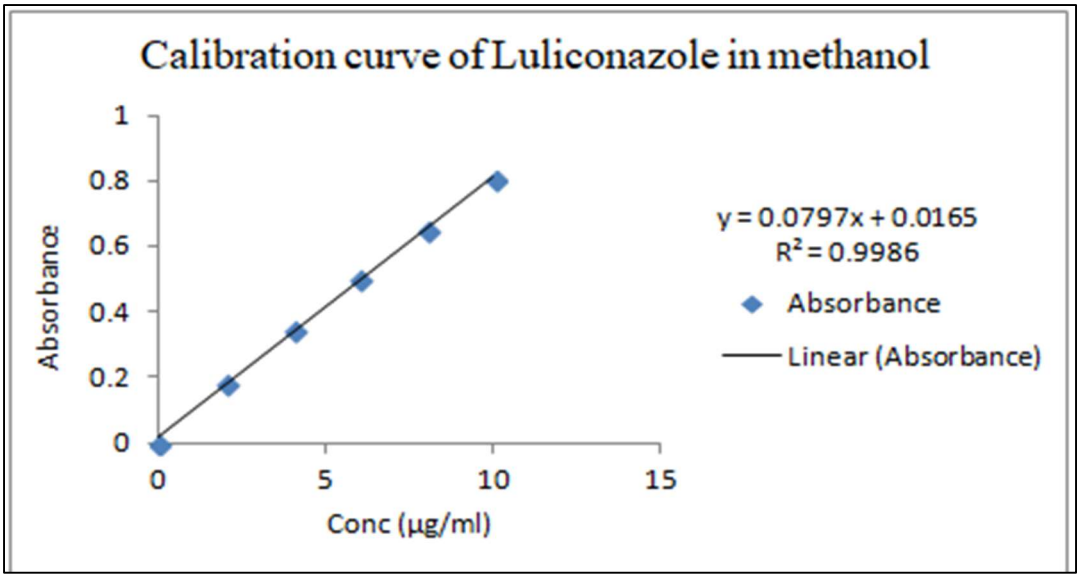


Fig. 6: Calibration curve of Luliconazole in methanol in Methanol

Estimation of λmax: A stock solution of Posoconazole (100 µg/ml) was prepared by dissolving 10 mg of the accurately weighed drug in methanol to a final volume of 100 ml. Subsequently, a 1 mL aliquot of this stock was withdrawn and diluted with dichloromethane to achieve a final working concentration of 10 µg/ml. UV spectrum was recorded from 400-200 nm. The λmax of drug was found to be 265.8nm in phosphate buffer solution maintained at pH 5.5. The overlay of posoconazole was performed to check the fixed wavelength of the drug at different concentrations. The spectral overlay demonstrated that all five concentrations 1.2, 2.4, 3.6, 4.8, and 6.0 µg/ml exhibited a consistent peak absorbance at a wavelength of 265.8 nm.

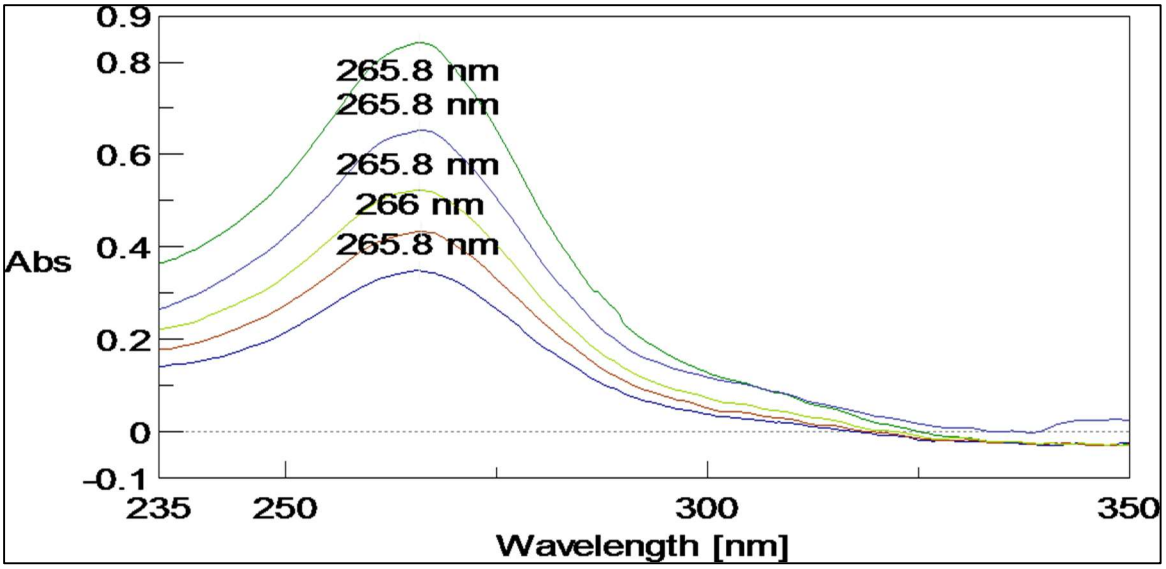


Fig. 7: Overlay of Posoconazole

Calibration curve of Posoconazole in Dichloromethane: A linear relationship was obtained in Beer-Lambert's plot of Posoconazole (y=0.005x+1.593 R^2=0.998). The calibration data is given in **Fig. 7 and Table 6**.

Table 6: Concentration and its Absorbance in Dichloromethane

Concentration (µg/ml)	Absorbance
0	0
2	0.1077
4	0.2032
6	0.3008
8	0.3865
10	0.4757

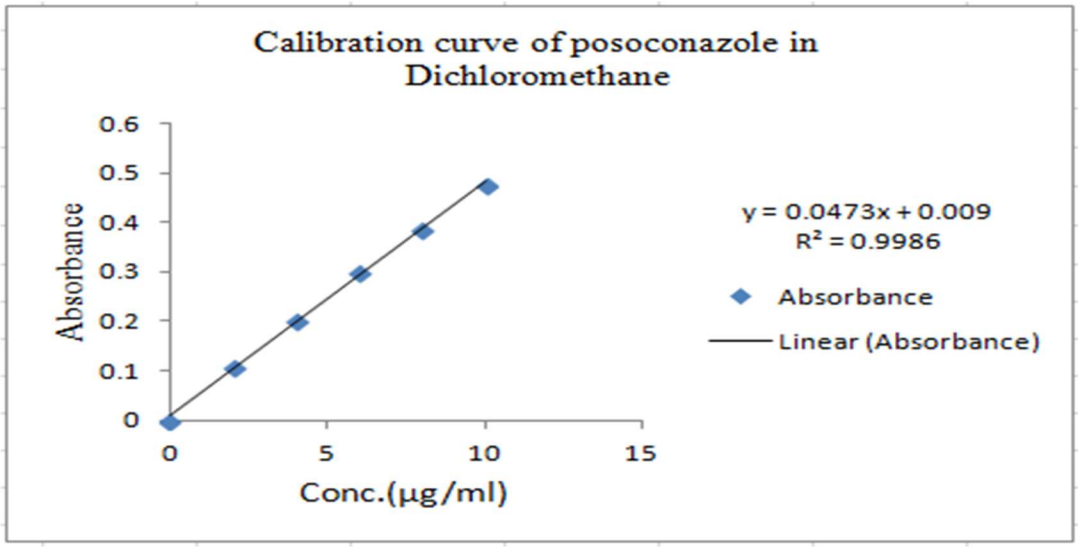


Fig. 8: Calibration curve of posoconazole in Dichloromethane

Evaluation of Optimized Batch:

Particle size:

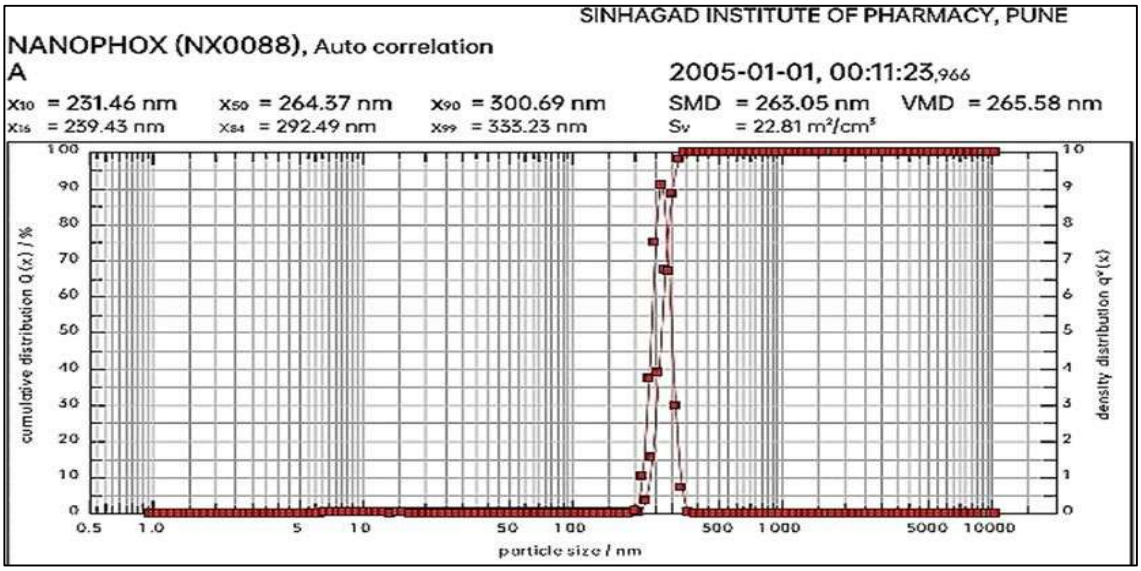


Fig. 9: Particle size of Luliconazole

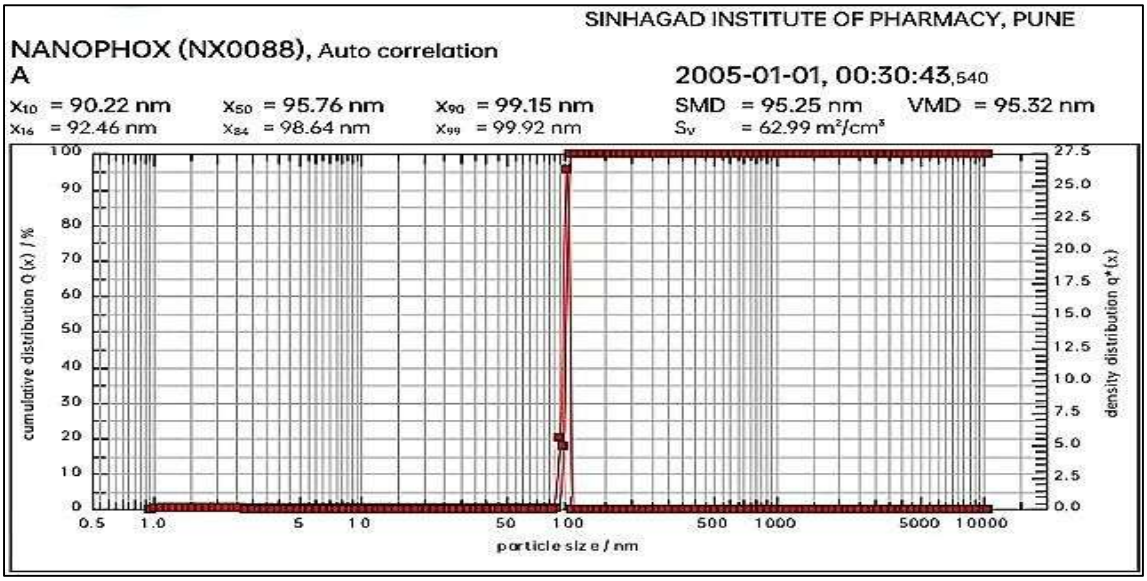


Fig.10: Particle size of Posoconazole

Mean particle size is a critical factor governing the stability and corneal permeability of Luliconazole and Posoconazole-loaded leciplex formulations. In this study, the Luliconazole-loaded particles exhibited a mean diameter of 264.37 nm. The relatively larger particle size contributes to stable dispersion but still remains within nanometric range, ensuring adequate permeability and reduced aggregation. The particle size of the Posoconazole 95.76 nm. The smaller particle

size enhances surface area, improving solubility and corneal penetration. The narrow distribution indicates uniformity and reproducibility of formulation. The cationic nature of the formulation promotes electrostatic attraction between the Luliconazole/Posoconazole leciplex particles and the negatively charged components of corneal mucin. Furthermore, maintaining an optimal particle size range is essential to minimize agglomeration, thereby enhancing the overall physical stability of the system.

Entrapment efficiency (%): The percentage of drug entrapment efficiency (%EE) was determined using the following mathematical expression, which relates the mass of the encapsulated drug to the total quantity utilized during the formulation process:

$$\text{Entrapment efficiency (weight \%)} = \frac{T-C}{T} \times 100$$

The drug entrapment efficiency (%EE) of the optimized batch was found to be 98.8%.

Stability: The optimized Luliconazole and Posoconazole Leciplex formulations demonstrated excellent stability, as evidenced by nanometric particle sizes preventing agglomeration, high entrapment efficiency ensuring minimal drug leakage, and favorable rheological properties. The positive surface charge facilitated electrostatic interaction with corneal mucin, enhancing adhesion and residence time, while the slightly acidic pH maintained drug solubility and compatibility. Collectively, these parameters confirm the physical and functional stability of the Leciplex system.

pH: The optimized Luliconazole and Posoconazole Leciplex formulations exhibited pH values of 4.94 and 4.82 respectively. Both formulations exhibit slightly acidic pH, which is important for maintaining drug stability and compatibility with excipient. The values fall within acceptable range for topical ocular and dermal formulations, ensuring minimal irritation upon applications. A pH lies within acceptable range for topical delivery to ensuring drug stability, compatibility and patient safety.

Viscosity: The viscosity of the prepared luliconazole leciplex was evaluated using a Brookfield viscometer equipped with a number 91 spindle. The sample chamber was filled with the formulation, and the spindle was rotated at 100 rpm. The observed viscosity indicated that the preparation attained the desired consistency. Furthermore, a decrease in viscosity corresponding to an increase in rotational speed confirmed that the formulation exhibits pseudo plastic, or shear-thinning, behavior, consistent with its rheological profile.

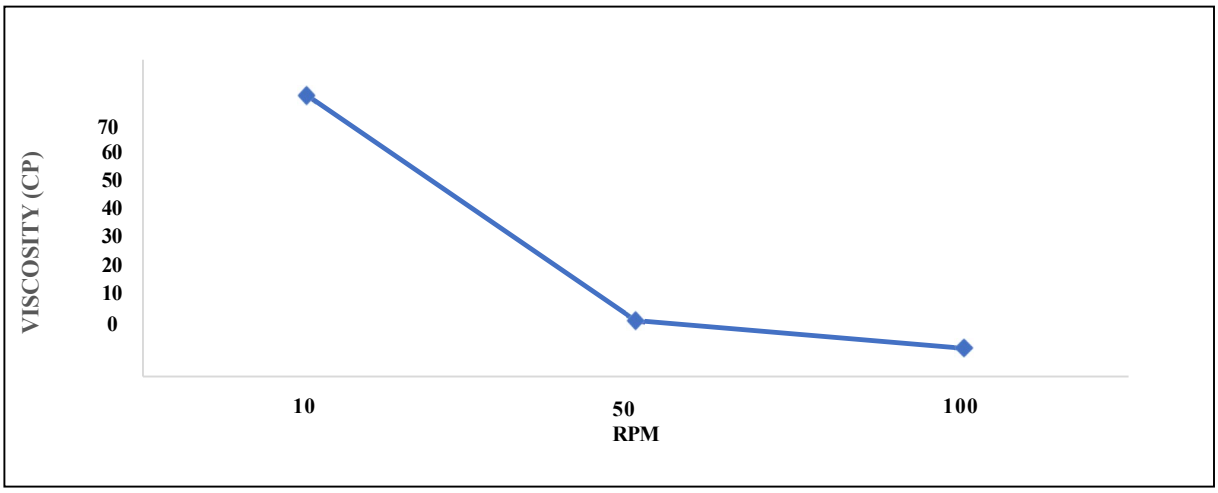


Fig. 11: Viscosity of Leciplex

Zone of Inhibition:

Table 7: Zone of inhibition

Formulation	Diameter (mm)		
Luliconazole	22	22	24
Posoconazole	23	24	24
Marketed cream	24	25	24

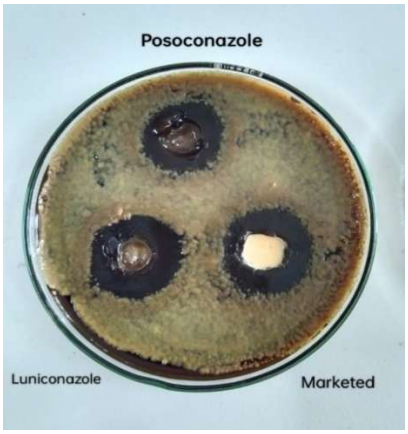


Fig.12: Reprentation of antifungal activity of different drug formulation

Histopathology study:

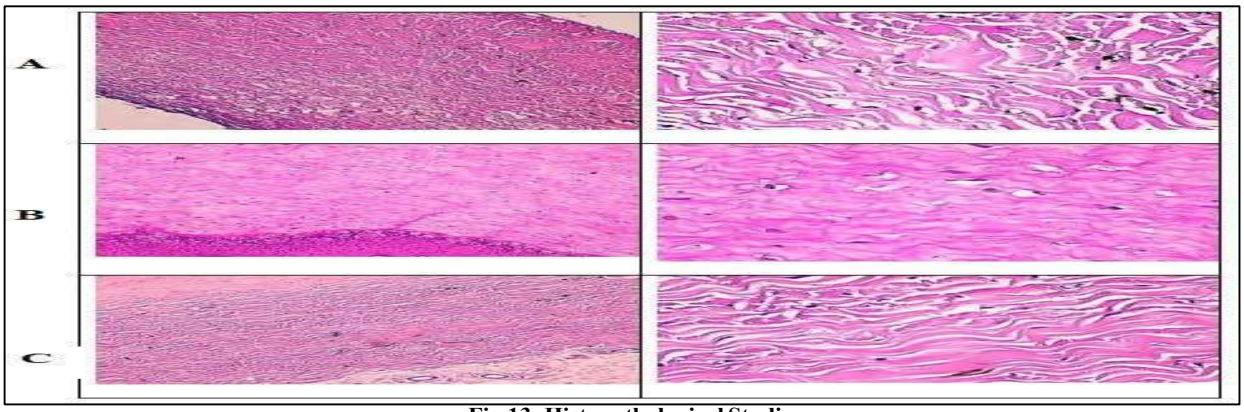


Fig.13: Histopathological Studies

Ex-Vivo Corneal Toxicity: Following an 8-hour exposure to the test formulations, histopathological evaluation of the goat corneas was conducted, as illustrated in **Figure 13**. The positive control group (A) exhibited a distinct separation between the epithelial layer and the stroma. Conversely, both the test formulation (B) and the negative control (C) maintained a normal corneal structure, indicating no significant tissue damage.

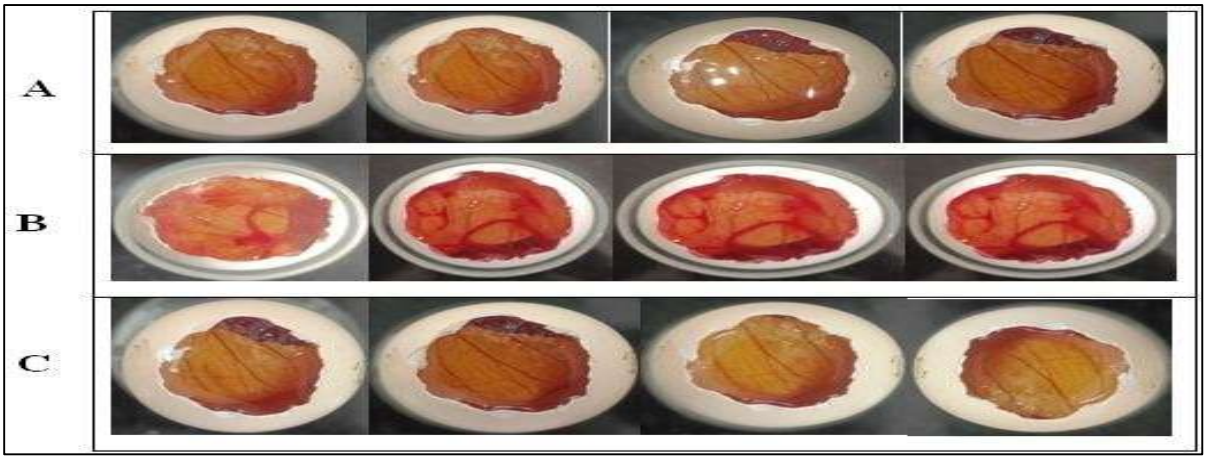


Fig.14: The HET-CAM assay was conducted by monitoring the time required for the manifestation of specific irritation endpoints: haemorrhage, vascular lysis, or coagulation. The experimental design included three groups: (A) a negative control treated with normal saline; (B) a positive control treated with 10% w/v KOH; and (C) the test group treated with the leciplex formulation

HET CAM Test: The HET-CAM assay serves as an effective in-vitro alternative to the Draize eye test for assessing the ocular irritation potential of drug-loaded formulations. In this study, irritation was classified based on the severity and time-to-onset of ocular tissue damage. Group A (negative control) exhibited no signs of irritation, whereas Group B (positive control, 10% KOH) induced severe reactions, confirming the high sensitivity of the chorioallantoic membrane (CAM) to irritants. The leciplex formulation (Group C) demonstrated neither irritation nor toxicity, supporting its suitability as a safe vehicle for ocular drug delivery.

DISCUSSION:

The present study focused on the formulation and evaluation of Leciplex, a novel lipid-based cationic nanocarriers system for delivering antifungal drugs such as Luliconazole and Posoconazole, aimed at overcoming limitations of conventional topical therapies including poor penetration, low bioavailability, frequent dosing, and adverse effects. Prepared using soy phosphatidylcholine, didodecyl dimethyl ammonium bromide (DDAB), and Transcutol

HP via a simple one-step fabrication technique, Leciplex demonstrated reproducibility, stability. Optimization trials yielded nanoparticles with desirable particle size, high entrapment efficiency, and controlled sustained release, enhancing permeation and retention compared to conventional formulations. Antifungal activity studies against clinically relevant strains showed significant efficacy, attributed to improved delivery and prolonged retention. In conclusion, the leciplex platform offers a superior approach to topical antifungal therapy by enhancing drug bioavailability and mitigating potential adverse effects. By improving therapeutic efficacy and facilitating a reduction in dosing frequency, this delivery system demonstrates significant potential as a robust platform for advanced dermatological treatment and a viable candidate for future clinical investigations.

CONCLUSION:

LeciPlex represents a promising lipid-based cationic nanocarrier system for the effective delivery of antifungal drugs such as Luliconazole and Posaconazole. The reviewed studies demonstrate that the one-step fabrication method produces stable nanoparticles with desirable physicochemical properties, including nanometric particle size, high drug entrapment efficiency, suitable viscosity, and acceptable pH. These characteristics contribute to improved drug solubility, enhanced penetration, prolonged residence time, and sustained drug release compared with conventional formulations. Furthermore, the formulations exhibited significant antifungal activity, excellent physical stability, and good safety profiles, as confirmed by histopathological and HET-CAM evaluations. Overall, LeciPlex has the potential to overcome the limitations of conventional antifungal therapy by improving bioavailability, reducing dosing frequency, and enhancing therapeutic efficacy. With further optimization, in vivo evaluation, and clinical studies, LeciPlex-based formulations may emerge as an effective and safe platform for advanced topical antifungal drug delivery.

ACKNOWLEDGEMENT:

We extend our sincere appreciation to the Sinhgad Institute of Pharmacy, Narhe, for providing the necessary infrastructure and experimental facilities essential for the successful completion of this research. Furthermore, we are deeply indebted to Lipoid GmbH (Germany) for their generous contribution of the Lipoid S 100 gift sample, which was fundamental to our study.

REFERENCES:

[1] Bernardes, T.F. and Bonfioli, A.A., 2010, May. Blepharitis. In Seminars in

ophthalmology (Vol. 25, No. 3, pp.79-83). Taylor & Francis.

[2] Clayton, J.A., 2018. Dry eye. New England Journal of Medicine, 378(23), pp.2212-2223.

[3] Date, A.A., Srivastava, D., Nagarsenker, M.S., Mulherkar, R., Panicker, L., Aswal, V., Hassan, P.A., Steiniger, F., Thamm, J. and Fahr, A., 2011. Lecithin-based novel cationic nanocarriers (LeciPlex) I: fabrication, characterization, and evaluation. Nanomedicine, 6(8), pp.1309-1325.

[4] Denning, D.W. and Bromley, M.J., 2015. How to bolster the antifungal pipeline. Science, 347(6229), pp.1414-1416.

[5] Drugbank:https://go.drugbank.com/drugs/DB08933

[6] Drugbank:https://go.drugbank.com/drugs/DB01263

[7] Drugbank:https://go.drugbank.com/drugs/DB14161

[8] Hartong, D.T., Berson, E.L. and Dryja, T.P., 2006. Retinitis pigmentosa. The Lancet, 368(9549), pp.1795-1809.

[9] Has, C. and Sunthar, P., 2020. A comprehensive review on recent preparation techniques of liposomes. Journal of liposome research, *30*(4), pp.336-365.

[10] Henderly, D.E., Freeman, W.R., Causey, D.M. and Rao, N.A., 1987. Cytomegalo virus retinitis and response to therapy with ganciclovir. Ophthalmology, 94(4), pp.425-434.

[11] Jones, T.M. (2018) 'Chapter 1. Preformulation studies', Drug Discovery, pp. 1–41.

[12] Keriwala, T.M., Sanghani, G., Dedania, Z. and Jain, V.C., 2017. Development and validation of simultaneous UV spectroscopy method for luliconazole and beclomethazone dipropionate in combined pharmaceutical dosage form, Pharma Sci. Monit, 10, pp.93-107.

[13] Lim, L.S., Mitchell, P., Seddon, J.M., Holz, F.G. and Wong, T.Y., 2012. Age-related macular degeneration. The Lancet, 379(9827), pp.1728-1738.

[14] Lam, D., Rao, S.K., Ratra, V., Liu, Y., Mitchell, P., King, J., Tassignon, M.J., Jonas, J., Pang, C.P. and Chang, D.F., 2015. Cataract. Nature reviews Disease primers, 1(1), pp.1- 15.

[15] Morrow, G.L. and Abbott, R.L., 1998. Conjunctivitis. American family physician, 57(4), p.735.

[16] Mabey, D.C., Solomon, A.W. and Foster, A., 2003. Trachoma. The Lancet, 362(9379), pp.223-229.

[17] Nandiyanto, A.B.D., Oktiani, R. and Ragadhita, R., 2019. How to read and interpret FTIR spectroscope of organic material. Indonesian Journal of Science and Technology, 4(1), pp.97-118.

[18] Nurman, S., Yulia, R., Irmayanti, Noor, E. and Candra Sunarti, T., 2019. The

optimization of gel preparations using the active compounds of arabica coffee ground nanoparticles. Scientia Pharmaceutica, 87(4), p.32.

[19] Parente, M.E., Ochoa Andrade, A., Ares, G., Russo, F. and Jiménez-Kairuz, Á., 2015. Bioadhesive hydrogels for cosmetic applications. International journal of cosmetic science, 37(5), pp.511-518.

[20] Porta, M. and Bandello, F., 2002. Diabetic retinopathy. Diabetologia, 45(12), pp.1617- 1634.

[21] PubChem:https://pubchem.ncbi.nlm.nih.gov/compound/18669

[22] Salama, A., Badran, M., Elmowafy, M. and Soliman, G.M., 2019. Spironolactone-loaded leciplexes as potential topical delivery systems for female acne: in vitro appraisal and ex vivo skin permeability studies. Pharmaceutics, 12(1), p.25.

[23] Shah, S., Dhawan, V., Holm, R., Nagarsenker, M.S. and Perrie, Y., 2020. Liposomes: Advancements and innovation in the manufacturing process. Advanced Drug Delivery Reviews, 154, pp.102-122.

[24] Shah, S.M., Ashtikar, M., Jain, A.S., Makhija, D.T., Nikam, Y., Gude, R.P., Steiniger, F., Jagtap, A.A., Nagarsenker, M.S. and Fahr, A., 2015. Leciplex, invasomes, and liposomes: A skin penetration study. International journal of pharmaceutics, 490(1-2), pp.391-403.

[25] Soni, V., Pandey, V., Tiwari, R., Asati, S. and Tekade, R.K., 2019. Design and evaluation of ophthalmic delivery formulations. In Basic Fundamentals of Drug Delivery (pp. 473-538). Academic Press.

[26] Thomas, P.A. and Geraldine, P., 2007. Infectious keratitis. Current opinion in infectious diseases, 20(2), pp.129-141.

[27] Thylefors, B. and Negrel, A.D., 1994. The global impact of glaucoma. Bulletin of the World Health Organization, 72(3), p.323.

[28] Wright, H.R., Turner, A. and Taylor, H.R., 2008. Trachoma. The Lancet, 371(9628), pp.1945-1954.