Title:

Full Title: Formulation and Characterization of Intranasal Gel-Loaded Liposomes of Chloramphenicol with Targeted Delivery

Short Title: Formulation and Characterization of Intranasal Gel-Loaded Liposomes of Chloramphenicol with Targeted Delivery

Authors:

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Abstract:

Bacterial meningitis is a severe and potentially life-threatening infection that requires prompt and effective treatment. Chloramphenicol is a broad-spectrum antibiotic commonly used to treat bacterial meningitis, but its poor blood-brain barrier permeability and dose-related toxicity limit its therapeutic efficacy. To overcome these limitations, liposomes were developed as a carrier system to deliver chloramphenicol directly to the brain. In this study, chloramphenicol-loaded liposomes were formulated using the Ether Injection method and optimized using a 2-factor, 3-leve 3^2 Factorial design. The liposomes were characterized for their particle size, entrapment efficiency, and In vitro drug release profile. The results suggest that chloramphenicol-loaded liposomes have the potential to improve the treatment of bacterial meningitis by enhancing the delivery of the antibiotic to the brain and reducing its toxicity. Chloramphenicol, a broad-spectrum antibiotic, is formulated as an intranasal gel for targeted brain delivery, leveraging the nose-to-brain pathway. The gel enhances drug bioavailability, bypassing the blood-brain barrier. *In-vitro* and *ex-vivo* studies show promising drug release and permeation profiles. This approach offers a potential treatment strategy for bacterial meningitis and CNS infections, improving therapeutic outcomes with reduced systemic side effects.

KEYWORDS: Chloramphenicol, Liposomes, Nose to Brain Delivery, Bacterial Meningitis

INTRODUCTION:

A novel drug delivery system can be defined as a new approach that combines innovative formulations, development and novel methodologies for delivering pharmaceutical compounds in the body that ensures safety and achieves its pharmacological effect. Compared to conventional drug delivery systems, novel drug delivery systems are advanced drug delivery systems. Preparing new pharmaceutical forms which having smaller particle size and increased permeability for targeted delivery is a key aspect of novel drug delivery system. The novel drug delivery system prolongs and enhances the therapeutic effect of drug which controls the distribution of drug is achieved by incorporating the drug in carrier system or changing the structure of the drug at molecular level. A novel drug delivery system can be defined as a new approach that combines innovative formulations, development and novel methodologies for delivering pharmaceutical compounds in the body that ensures safety and achieves its pharmacological effect. Compared to conventional drug delivery systems, novel drug delivery systems are advanced drug delivery systems. Preparing new pharmaceutical forms which having smaller particle size and increased permeability for targeted delivery is a key aspect of novel drug delivery system. The novel drug delivery system prolongs and enhances the therapeutic effect of drug which controls the distribution of drug is achieved by incorporating the drug in carrier system or changing the structure of the drug at molecular level. Gels consist of polymer network that absorbs and retain vast quantities of water. Hydrophilic groups in the polymeric network hydrate in aqueous environments to form a Gel structure. Another description is that it is a polymeric material that will not dissolve in water but shows the ability to expand and keep a large amount of water inside its structure. Because of their high-water content, they are quite flexible, much like genuine tissue. The hydrophilic functional group affixed to the polymeric backbone gives its ability to absorb water, whilst the crosslinks interconnected network chains provide it its opposition to dissolution. A type of arthritis called gout is caused by the formation of monosodium urate (MSU) crystals in the joints. When the concentration of uric acid at physiological pH exceeds its solubility limit, which is 6.7-7 mg/dl, it may nucleate and form crystals in tissues and joint.[1-3]

Pre-Formulation Studies:

The Physicochemical properties of the drug play a very important role in performance of the drug and the development of dosage form. Hence, in order to develop a safe, stable and effective dosage form the Performulaion study of Chloramphenicol was carried effectively.

Melting Point:

The melting point of Chloramphenicol was determined by Digital Melting Point Apparatus.[4]

Solubility:

The solubility of Chloramphenicol was tested in different solvents like Distilled water, Methanol at ambient temperature, dissolving a specific amount of medication (10mg) in 10ml of each solvent. The solubility was detected visually and also using UV-visible spectroscopy.[5]

UV-Visible Spectroscopy[6-7]:

Determination of λ max of Chloramphenicol in Phosphate Buffer 7.4:

Chloramphenicol was weighed 100 mg accurately and taken in 100 ml volumetric flask and dissolved in Phosphate Buffer 7.4 up to mark. The final 1000 µg/ml concentration solution was prepared and used as a stock solution. From the stock-I, 10 ml sample was withdrawn by pipette and diluted to 100 ml by using Phosphate Buffer 7.4 and stock-II was prepared having concentration of 100 µg/ml. From the stock-II sample was withdrawn analyzed under UV Spectrophotometer of UV 200-400 nm. The spectrum was obtained and the absorbance for the λ max detected in Phosphate Buffer 7.4

Calibration curve determination by UV-Vis Spectrophotometry:

Preparation of Stock Solution: 1. 10 mg Chloramphenicol weighed accurately and dissolved in small amount of Phosphate Buffer 7.4 and volume was made up to 10 ml with it. (Concentration 1000 µg/ml). 2. From stock-I, 1 ml sample was withdrawn by pipette and diluted to 10 ml with Phosphate buffer 7.4. (Concentration 100 µg/ml) From stock-II, working solution 2,4,6,8 and 10 µg/ml concentration dilutions were prepared. The absorbance of dilutions was measured at λ max by UV Visible Spectrophotometer.

Differential Scanning Calorimetry:

Differential Scanning Calorimetry (DSC) is a thermal analysis technique used to study the thermal properties of materials. Here's a general outline for conducting DSC analysis on Chloramphenicol. The interaction studied were carried out using differential scanning calorimetry and DSC curve represented as heat flow v/s temperature.

Drug- Excipient Compatibility Study by FTIR Spectroscopy:[8-9]

For the purpose of identifying any potential chemical interaction between the drug and the excipients, a method called infrared spectra was used. A physical mixture (1:1) of the drug and its excipients was prepared and mixed. The mixture was scanned using Bruker FTIR Spectrophotometer from 3500-500 cm-1. IR spectrum observed the physical combination was compared to that of the pure drug and excipients

Factorial Design

The 3^2 Full factorial design was used for the optimization of Excipients for Chloramphenicol liposomes. With the aid of the software Design-Expert® (Version 13), the trial design was completed. In these design, two factors at 3 different levels were evaluated which gives nine combinations. The amount Polymer Chitosan coating agent (X1) and amount of Carbopol 943as gelling agent (X2), were selected as independent variables. Each factor is studied at low, intermediate and high levels. The dependent variable selected for study is % Entrapment efficiency (Y1), Particle Size (Y2) and *In-Vitro* drug release

Table No: 1 Formulation Batches of Liposomal Gel as per Three Raised to Two (3^2) Factorial Design

SR NO	Formulation Batches	A: Chitosan	B: Carbopol 934
1.	F 1	215	60
2.	F 2	30	40
3.	F 3	400	40
4.	F 4	215	40
5.	F 5	30	20
6.	F 6	400	60
7.	F 7	215	20
8.	F 8	400	20
9.	F 9	30	60

***Note-** Quantity expressed in milligram

Formulation of Chloramphenicol Liposome by Ether Injection Technique[10-11]:

Chloramphenicol Liposomes were formulated using an ether injection technique. Accurately measured amount of Carbopol 934 and Chitosan were dissolved in 6 ml diethyl ether, which combined with 2 ml methanol containing 10 mg of Chloramphenicol. The resulting solution was taken into micro syringe and slowly injected into10 ml of phosphate buffer having pH 7.4. Then, the solution was continuously stirred with temperature maintained at 60-650 C. The difference in temperature between the phases causes rapid vaporization and resulting in the formation of liposomes.

Post Formulations Studies:[12-15]

Evaluation of Chloramphenicol Liposomes:

Entrapment Efficiency:

Centrifugation method was used to determined percentage entrapment efficiency of Chloramphenicol Liposomes. Freshly prepared 5 ml Liposomes was taken in centrifuge tube and centrifuged at 9000 rpm for 45 minutes (REMI Instrument). 1 ml supernatant was separated which containing free drug and diluted with methanol. The concentration of free drug in supernatant layer was analyzed at wavelength of 234 nm by UV Spectrophotometer (Jasco V-530). % Entrapment Efficiency was calculated by using formula –

$$\textbf{\textit{Entrapment Efficiency}} = \frac{\textbf{\textit{Total amount of drug added} - \textbf{\textit{Drug in supernatant}}}}{\textbf{\textit{Total amount of drug added}}} \times \mathbf{100}$$

Scanning Electron Microscopy:

Scanning Electron Microscopy was carried out for best formulation F7 to determine the surface morphology of Liposomes.

Mean Particle Size:

The mean particle size of Liposomes was determined by Particle Size Analyzer (Horiba SZ-100). 6.9 Characterization of Liposomal Gel

Physical characterization:

The prepared Gel formulations were inspected visually for their colour, Odour, Appearance and Solubility.

Determination of pH: The pH of Gel formulations was determined by digital pH meter. One gram of gel was dissolved in 25 ml of distilled water and the electrode was then dipped in to gel formulation for 30 min until constant reading obtained. And constant reading was noted. The measurement of pH of each formulation was done in triplicate and average values were calculated.

Spreadability: Two glass slides of standard dimensions (6×2) were selected. The Gel formulation whose Spread ability had to be determined was placed over one of the slides. The second slide was placed over the slide in such a way that the formulation was sandwiched between them across a length of 6 cms along the slide. 100 grams of weight was placed up on the upper slide so that the Gel formulation between the two slides was traced uniformly to form a thin layer. The weight was removed and the excess of the Gel formulation adhering to the slides was scrapped off. The lower slide was fixed on the board of the apparatus and one end of the upper slide was tied to a string to which 20 gram load could be applied with the help of a simple pulley. The time taken for the upper slide to travel the distance of 6 cms and separate away from lower slide under the direction of the weight was noted. The experiment was repeated and the average of 6 such determinations was calculated for each Gel formulation.

$$Spreadability = m.\frac{l}{t}$$

Viscosity: The measurement of viscosity of the prepared Gel was done using Brookfield digital Viscometer. The viscosity was measured using spindle no. 6 at 10 rpm and 250C. The sufficient quantity of gel was filled in appropriate wide mouth container. The Gel was filled in the wide mouth container in such way that it should sufficiently allow to dip the spindle of the viscometer. Samples of the Gel were allowed to settle over 30 min at the constant temperature (25 ±100C) before the measurements.

Drug content: Accurately weighed Liposomal Gel equivalent to 100 mg Chloramphenicol was taken in beaker and added 20 ml of phosphate buffer pH 7.4. This solution was mixed thoroughly and filtered using Whatman filter paper no.1. Then 1.0 ml of filtered solution was taken in 10 ml capacity of volumetric flask and volume was made upto 10 ml with phosphate buffer pH 7.4. This solution was analyzed using UV spectrophotometer at λmax 258 nm & 315nm.

Zeta Potential: The surface charges on Chloramphenicol loaded in Liposomal Gel was determined by using Zeta Potential Analyzer (Horiba SZ 100)/ ZS XPLORER. The charge present on Gel preparation was determined at 250C and analysis time was kept for 60 seconds.

***In -Vitro* Drug Release of Liposomal Gel:** The controlled release profile of Chloramphenicol loaded Gel membranes were determined by USP type-II dissolution apparatus. To determine the percent release, dissolution studies were performed at normal skin pH 5.5 and infected skin pH 7.4. Weighed Gel membranes were immersed separately into the dissolution media of 500 mL phosphate buffer solutions (pH 6.5 & 7.4) at a temperature of 32 ± 0.5 °C. The content will be rotated at 50 revolutions per minute. The samples were withdrawn using graduated pipette after specific time intervals with the replacement of fresh dissolution media. Samples were filtered, diluted and analyzed at 315 nm & 258 nm using UV-Visible Spectrophotometer.

***Ex-Vivo* Permeation Study:** Skin permeation and deposition study were carried out in triplicate by using Franz diffusion cell with an effective area of 1.76 cm2. The rabbit skin was mounted between with stratum corneum facing donor compartment. Phosphate buffer of pH 7.4 was filled up to 12ml with continuous stirring while the temperature of whole assembly was maintained at 32 ± 1°C by circulating the water at a constant temperature in the outer jacket. Due to loss of heat in connected plastic tubes of thermostat temperature had to be set at 37 °C to attain final temperature at 32 ± 1 °C.

Results and Discussion:

Pre-formulation Evaluation

Determination of Melting Point:

The melting point of Chloramphenicol was determined by using Digital Melting Point Apparatus and was found to be 149℃ & 153℃ respectively.

Table No: 2: Determination of Melting Point.

Sr. No	Standard M.P. (℃)	Observed M.P. (℃)	Mean M.P. (℃)
1	Chloramphenicol 149℃-153℃	149.30℃	152.18℃
2		151.71℃	
3		152.53℃	

Solubility:

API	Solubility
Chloramphenicol	○ Ethanol: ~150 mg/mL ○ Methanol: Soluble ○ DMSO: Soluble ○ Propylene glycol: Soluble ○ Acetone: Slightly soluble

Table No: 3 Determination of Solubility Point.

UV-Visible Spectroscopy:

Determination of λ max

Determination of λ max of Chloramphenicol in Phosphate Buffer 7.4:

The λ max was determined in Phosphate Buffer 7.4.

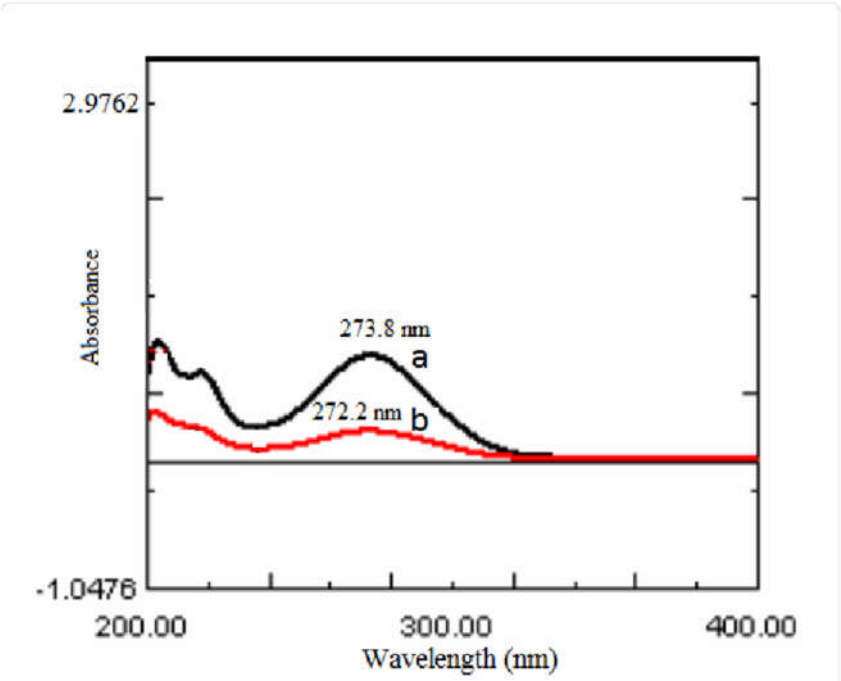

Fig No: 1 Calibration curve determination by UV-Vis Spectrophotometry of Chloramphenicol in Phosphate Buffer 7.4:

The table shows the absorbance value of different concentration of Chloramphenicol in Phosphate Buffer 7.4 at wavelength 273nm.

Table No: 4 Calibration curve determination by UV-Vis Spectrophotometry of Chloramphenicol in Phosphate Buffer 7.4

SR. NO	Concentration(µg/ml)	Absorbance
1.	2	0.0001
2.	4	0.0017
3.	6	0.0038
4.	8	0.0061
5.	10	0.0085

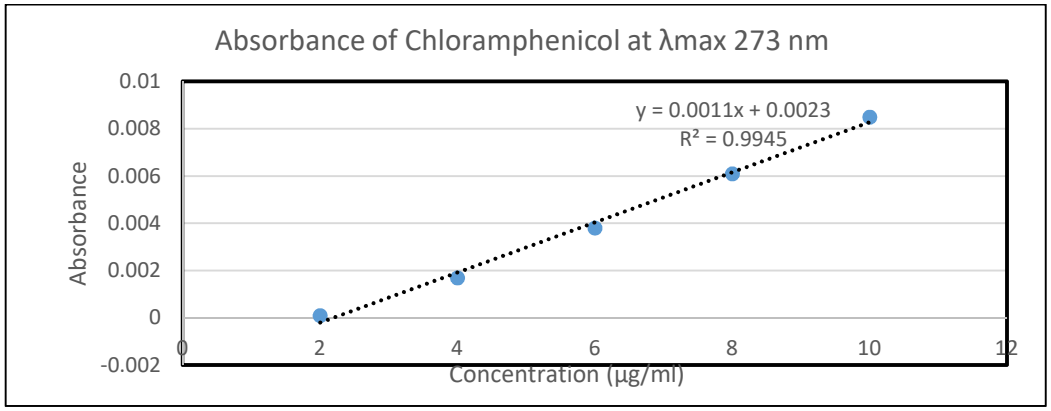

Fig. No: 2 Calibration curve of Chloramphenicol in Phosphate Buffer 7.4.

Interpretation of Differential Scanning Calorimeter of Chloramphenicol:

The DSC studies was carried out for pure drug Chloramphenicol. The thermogram revealed that occurrence of sharp endothermic peak at 180.53°C.

Table No: 5 DSC Thermogram Peaks

Drug	Melting Point/ temperature (°C)		
Chloramphenicol	Peak Onset	Peak	Peak Endset
	178.70°C	178.30°C	180.53°C

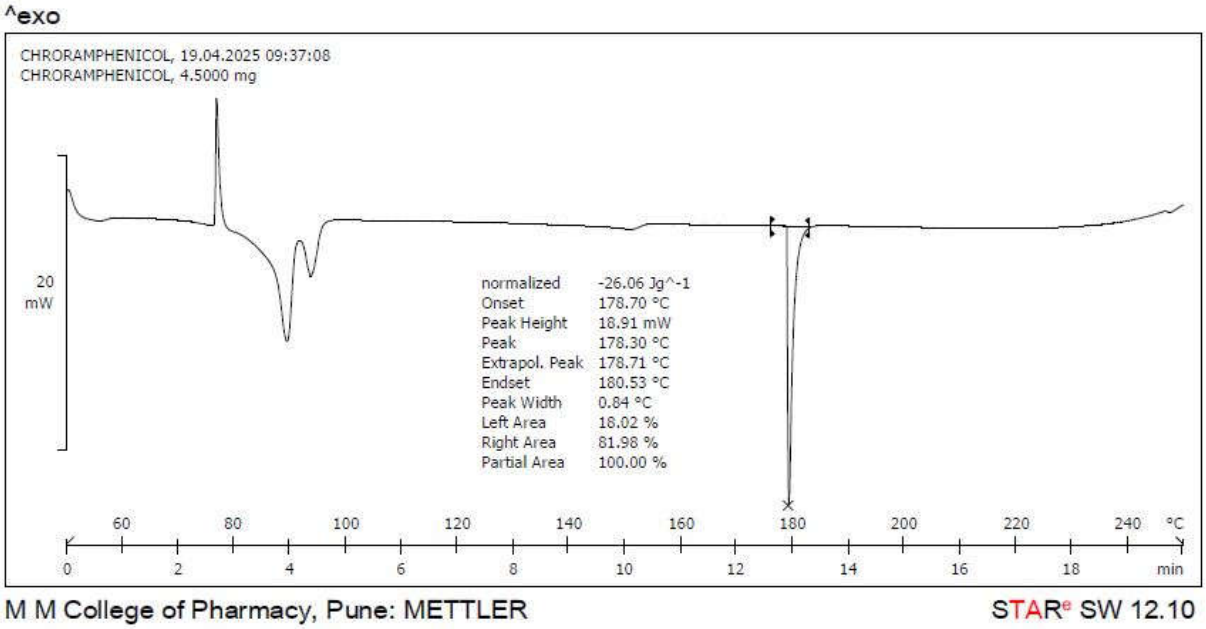

Fig No: 3 DSC thermogram of Chloramphenicol

Compatibility study of Chloramphenicol by FTIR:

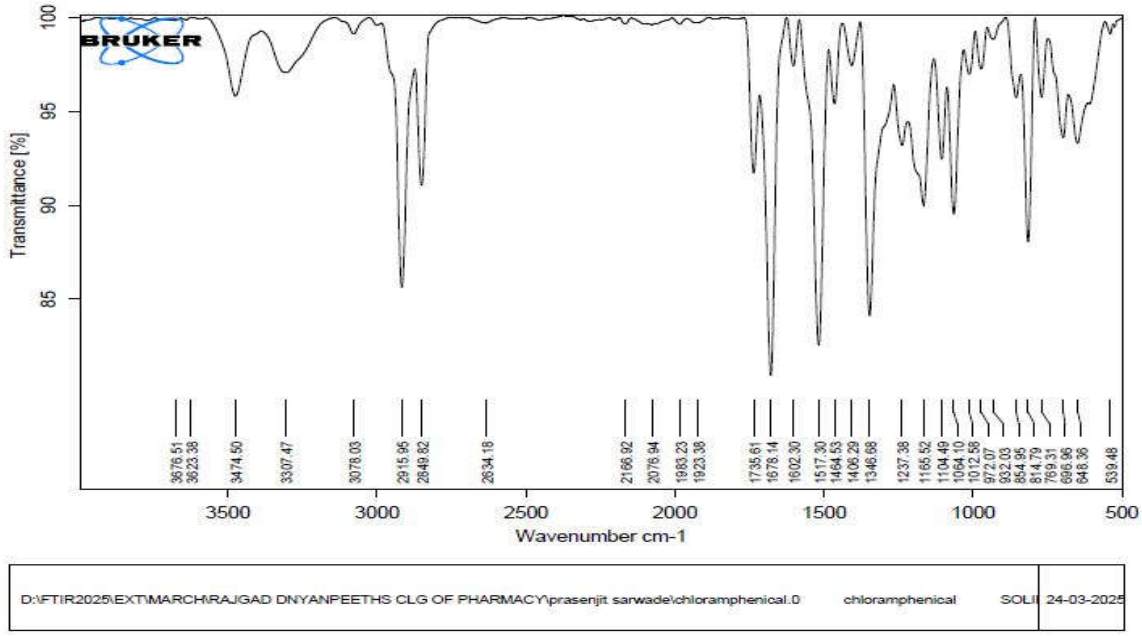

Fig No: 4 FTIR spectra of Chloramphenicol.

Table No: 6 Interpretation of FT-IR Spectra of Chloramphenicol

Functional Group	Standard Range (cm^{-1})	Observed Range (cm^{-1})
R-CH_3	3000-2850	2873
C≡N	2300-2200	2234
C=C	1700-1600	1697, 1602
R- O -R	1300-1175	1216
R- S -R	680-610	612
C= N	1790-1690	1697
COOH	1760-1690	1697

Compatibility study of Chitosan by FTIR:

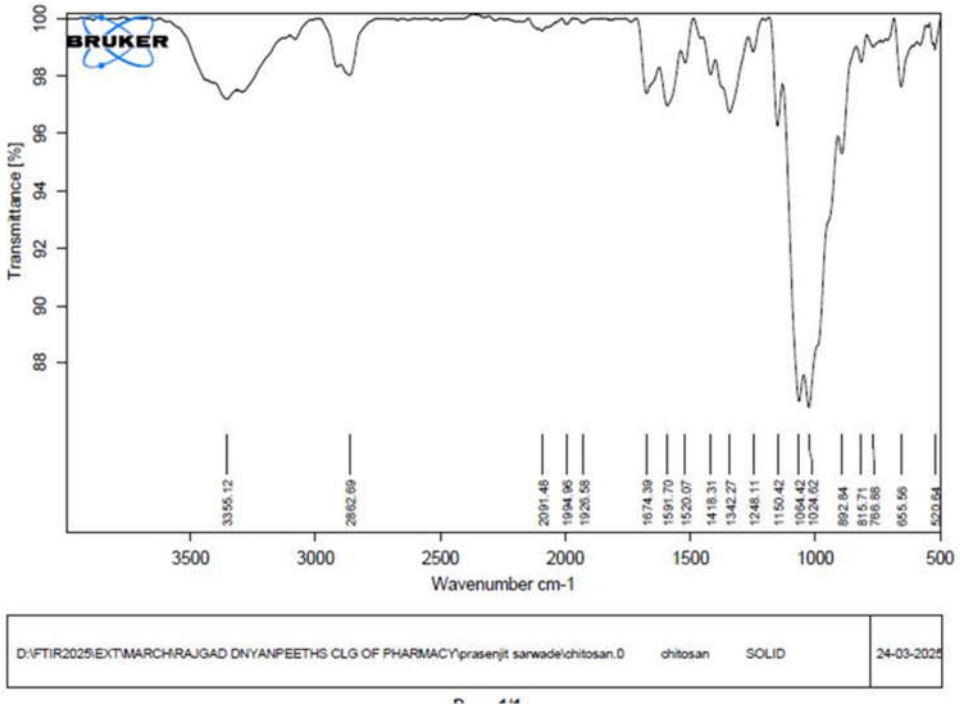

Fig No: 5 FTIR spectra of Chitosan.

Table No: 7 Compatibility study of Carbopol 934 by FTIR

Functional Group	Standard Range (cm^{-1})	Observed Range (cm^{-1})
R-CH_3	3000-2850	2869
C=C	1600-1500	1505
C-C	1445-1405	1417
COOH	1760-1690	1706
C-H	2970- 2850	2950

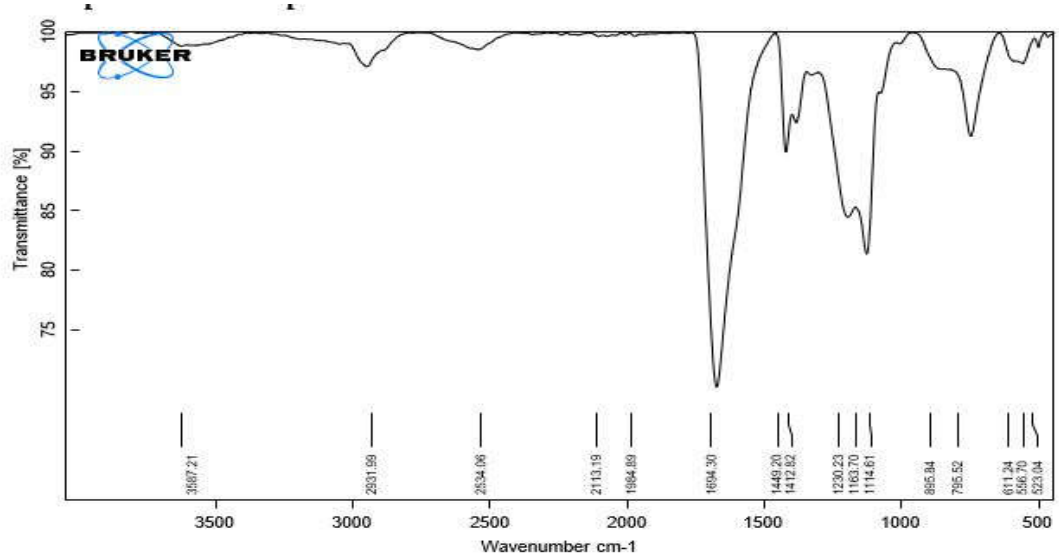

Fig No: 6 FTIR spectra of Carbopol 934

Table No: 8 Interpretation of FT-IR Spectra of Carbopol 934

Functional Group	Standard Range (cm^{-1})	Observed Range (cm^{-1})
R-CH_3	3000-2850	2931
C=C	1680-1600	1694
C-C	1445-1405	1412
COOH	1760-1690	1694
C-H	2970- 2850	2931

Compatibility study of HPMC by FTIR:

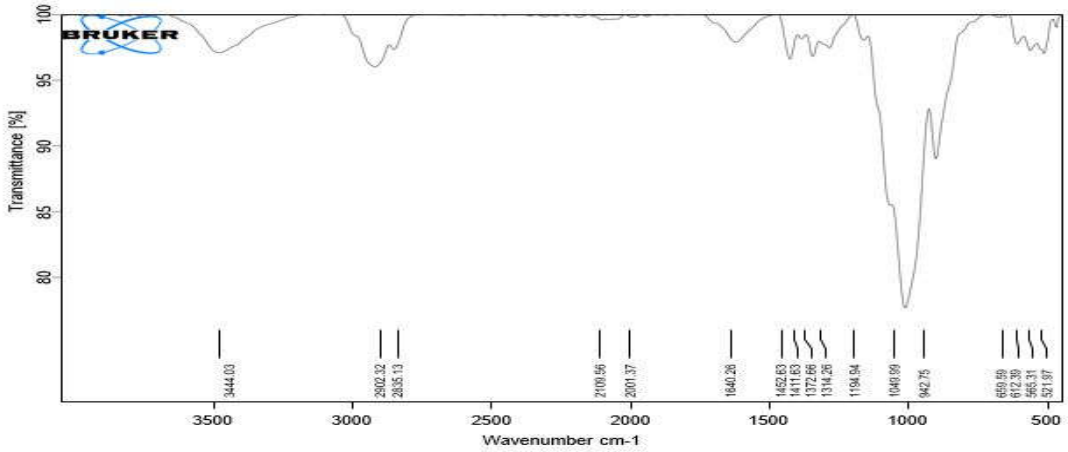

Fig No: 7 FTIR spectra of HPMC

Table No: 9 Interpretation of FT-IR Spectra of HPMC

Functional Group	Standard Range (cm^{-1})	Observed Range (cm^{-1})
R-CH_3	3000-2850	2902
C=C	1680-1600	1640
C-C	1445-1405	1411
COOH	1750-1650	1640
O-H	3500-3200	3444
R-O-R	1300-1175	1194
C-H	2970- 2850	2902

Characterization of Liposomes:

Physical Characterization of Liposomes:

Table No: 10 Physical Characterization of Liposomes.

Sr. No.	Tests	Results
1.	Colour	Translucent White
2.	Odour	odorless
3.	Texture	Spherical

2 Entrapment Efficiency-

The entrapment efficiency of all Liposomes formulations batches F1 to F9 ranged Between 87.61% to 92.98% which is shown in table 7.8. The % entrapment efficiency of optimized batch F7 were found to be 92.98%.

Table No: 11 Entrapment Efficiency

Formulation Batch	Entrapment Efficiency (%)
F1	87.61 %
F2	88.75%
F3	93.26%
F4	92.96%
F5	87.63%
F6	92.75%
F7	92.98%
F8	93.47%
F9	90.68%

Scanning Electron Microscopy-

The SEM images of Chloramphenicol are showing spherical structure with smooth surface and porous nature, as shown in figure no: 8

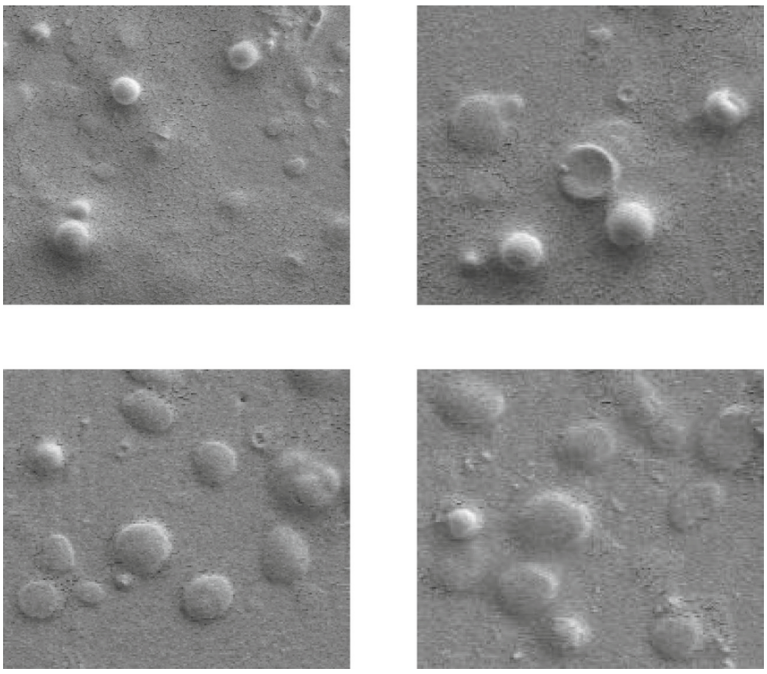

Fig No: 8 SEM of Liposomes

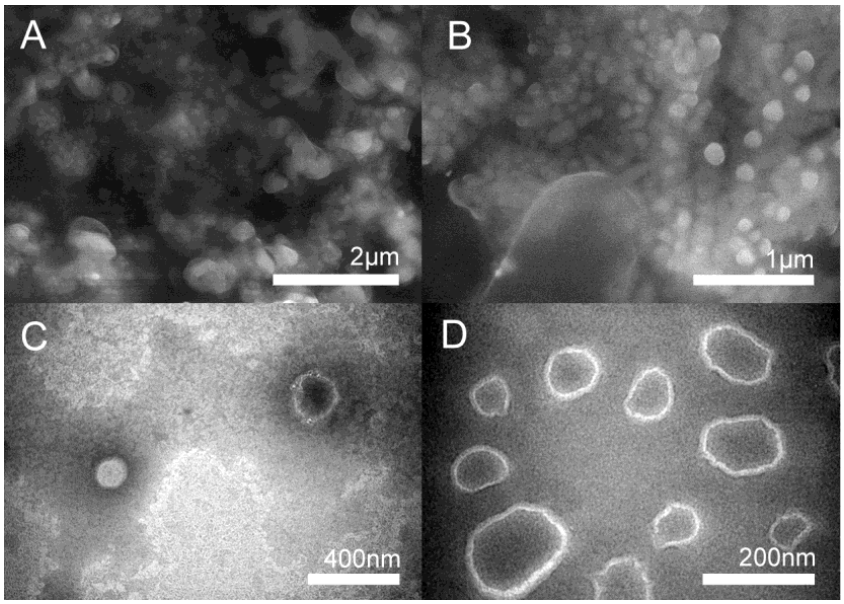

Fig. No: 9 SEM Images of Liposome F7 batch

Mean Particle Size: -

The mean particle size of Liposomes of Chloramphenicol was as shown in table 7.13. The mean particle of F7 batch was found to be 219.1 nm.

Z-Average (nm)	: 219.1
Peak 1 Mean by Intensity ordered by area (nm)	: 253.1
Peak 2 Mean by Intensity ordered by area (nm)	: 46.94
Peak 3 Mean by Intensity ordered by area (nm)	:
Di (10)	: 39.89
Di (50)	: 192.9
Di (90)	: 305.1

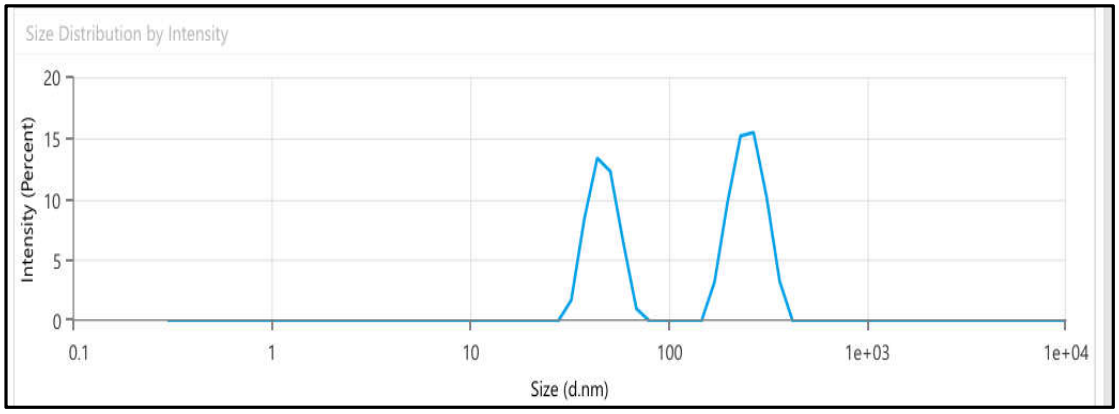

Fig. No: 10: Particle size of F7 batch of Liposomes.

7.6 Liposomal Gel:

7.6.1 Physical Characterization of Liposomal Gel:

Table No: 12 Physical Characterization of Liposomal Gel

Sr. No.	Tests	Results
1.	Colour	Translucent White
2.	Odour	odorless
3.	Appearance	Smoothy appears
4.	Solubility	Freely Soluble in water

pH:

The pH was measured in each gel, using a pH meter, which was calibrated before each use with standard buffer solutions at pH 5-7. The electrode was inserted in to the sample 10 min priors to taking the reading at room temperature.

Table No: 13 pH of Gel batches.

SR NO	Formulation Batches	pH
1.	F 1	6.8
2.	F 2	6.7
3.	F 3	6.6
4.	F 4	6.52
5.	F 5	6.04
6.	F 6	6.89
7.	F 7	6.42
8.	F 8	6.91
9.	F 9	6.73

Spreadability:

Table No: 14 Spreadability of Liposomal Gel

SR NO	Formulation Batches	Spreadability (gcm/sec)
1.	F 1	12.30
2.	F 2	14.53
3.	F 3	12.47
4.	F 4	13.87
5.	F 5	14.56
6.	F 6	13.54
7.	F 7	12.51
8.	F 8	14.96
9.	F 9	13.67

Viscosity:

The viscosity of the Gel was obtained by using Brookfield digital viscometer.

Table No: 15 Viscosity of Liposomal Gel.

SR NO	Formulation Batches	Viscosity
1.	F 1	7398 cPs
2.	F 2	10598cPs
3.	F 3	5599cPs
4.	F 4	7798cPs
5.	F 5	4039cPs
6.	F 6	4599cPs
7.	F 7	10998cPs
8.	F 8	3399cPs
9.	F 9	4599cPs

Drug Content:

The % drug content of all nine batches of Gel was ranged between 75.43 % to 91.17 % which shows presence of drug in Gel. The % drug content of F 7 optimized batch was found to be 91.17%. The % drug content is shown in following table 7.16.

Table No: 16 Drug Content Studies of Liposomal Gel

Sr no	Formulation Batches	Drug Content
1.	F 1	75.43%
2.	F 2	88.39%
3.	F 3	82.23%
4.	F 4	86.71%
5.	F 5	87.53%
6.	F 6	83.91%
7.	F 7	91.17%
8.	F 8	89.20%
9.	F 9	82.57%

Zeta Potential:

The zeta potential of F 2 batch was found to be – 10.54 mV. The zeta potential analysis showed that charge present on Gel formulation was stable.

Table No.17: Sample Details for Zeta potential.

Sample Name:	Liposomal Gel		
Project Name:	Calibration_06.09.2025		
Date and Time:	Friday, September 14, 2025 8:57:04 PM		
Type:	Zeta Instrument	**Result Source:**	Instrument
Cell Name:	ZEN1002 25	**Temperature (°C):**	ZEN1002 25
Material Name:	Polystyrene latex	**Dispersant Name:**	Polystyrene latex
Material RI:	1.59	**Dispersant RI:**	1.59
Material Absorption:	0.01	**Dispersant Viscosity (cP):**	0.01
Sample Name:	Zeta Instrument	**Dispersant Dielectric Constant**	Water

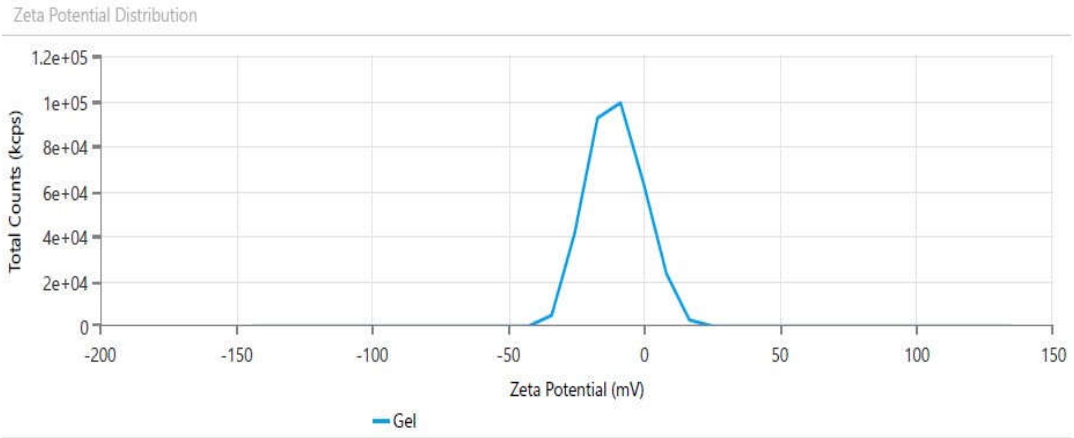

Fig. No: 11 Zeta Potential Peak

Table No: 18 Standard result of Zeta Potential.

Name	Mean	Std. Deviation	RSD	Minimum	Maximum
Zeta Potential (mV)	-10.54	-	-	-10.54	-10.54
Zeta peak 1 Mean (mV)	-10.54	-	-	-10.54	-10.54
Conductivity (mS/cm)	0.05562	-	-	0.05562	0.05562

Wall Zeta Potential (mV)	0	-	-	0	0
Zeta Deviation (mV)	10.06	-	-	10.06	10.06
Derived Mean Count Rate (kcps)	2.678E+05	-	-	2.678E+05	2.678E+05
Reference Beam Count Rate (kcps)	1777	-	-	1777	1777
Quality Factor	1.771	-	-	1.771	1.771

7.6.7 *In- Vitro* Drug Release from Liposomal Gel:

The *In-vitro* drug release of Liposomal Gel was found in range of 70.40% to 82.74138% in phosphate buffer pH 7.4 for 6 hours which is shown in following table 7.19. The *in-vitro* drug release of F 7 batch of Gel was found high % drug release.

Table No: 19 *In -Vitro* Drug Release of Liposomal Gel

Sr. No	Time (Min)	F 5 (%)	F 7 (%)	F 8 (%)
1.	30	5.05172	8.65517	6.17241
2.	60	11.12069	15.2069	13.17241
3.	120	19.5862	23.22414	24.91379
4.	180	29.74138	37.15518	36.51724
5.	240	41.77586	48.4138	49.5862
6.	300	55.32758	66.82759	63.06896
7.	360	70.4079	82.74138	78.4427

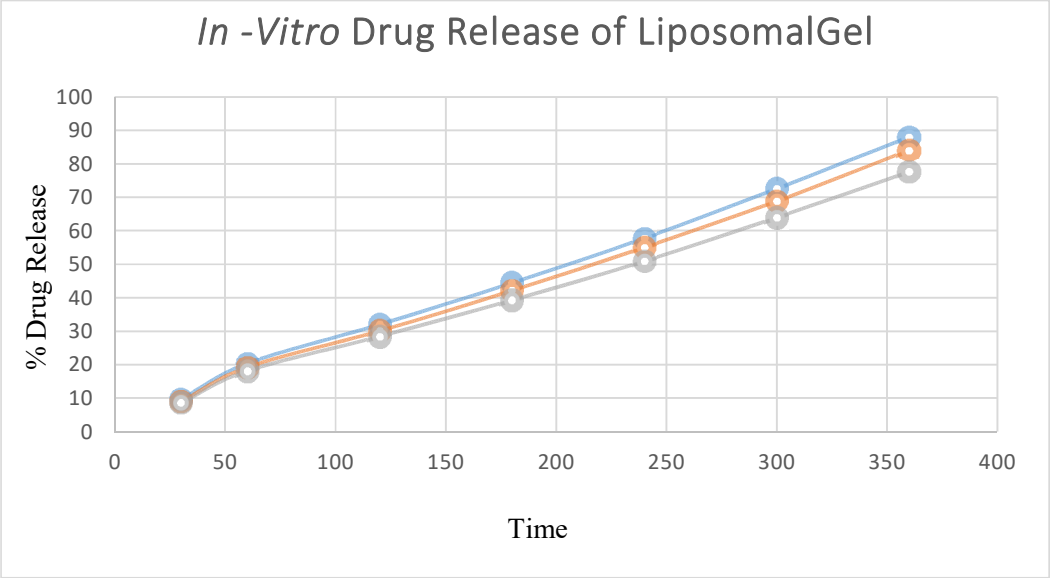

Fig. No: 12 In -*Vitro* Drug Release of Liposomal Gel

***Ex-Vivo* Permeation Study-:**

The *Ex-vivo* permeation studies of F 5, F 7 and F 8 was found in range between 77.651% to 88.03%. From ex-vivo permeability study showed that F 7 batch showed high permeability of Gel as compare to Batch F 5 and F 8.

Table No: 20 Ex-*Vivo* Permeation Study of Liposomal Gel.

Sr. No	Time (Min)	F 5 (%)	F7 (%)	F 8 (%)
1.	30	8.58662	9.65517	8.96552
2.	60	18.1211	20.3621	19.1897
3.	120	28.4314	31.9828	30.069
4.	180	39.2763	44.4138	42.1035
5.	240	50.9314	57.7759	55.069

6.	300	63.9832	72.58622	68.8448
7.	360	77.6556	88.0345	84.1035

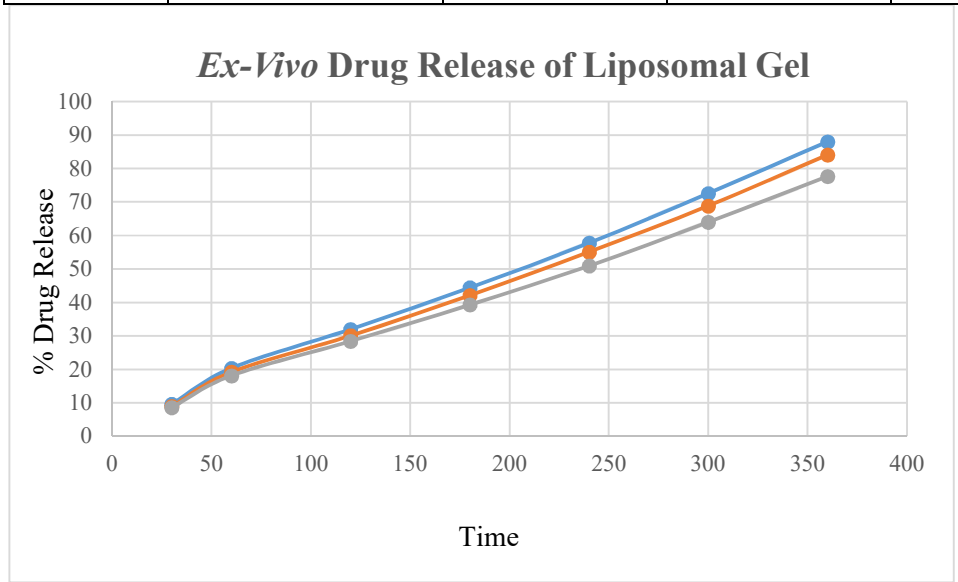

Fig. 13: *Ex-Vivo* Permeation Study of Liposomal Gel

Compatibility study of Gel formulation by FTIR:

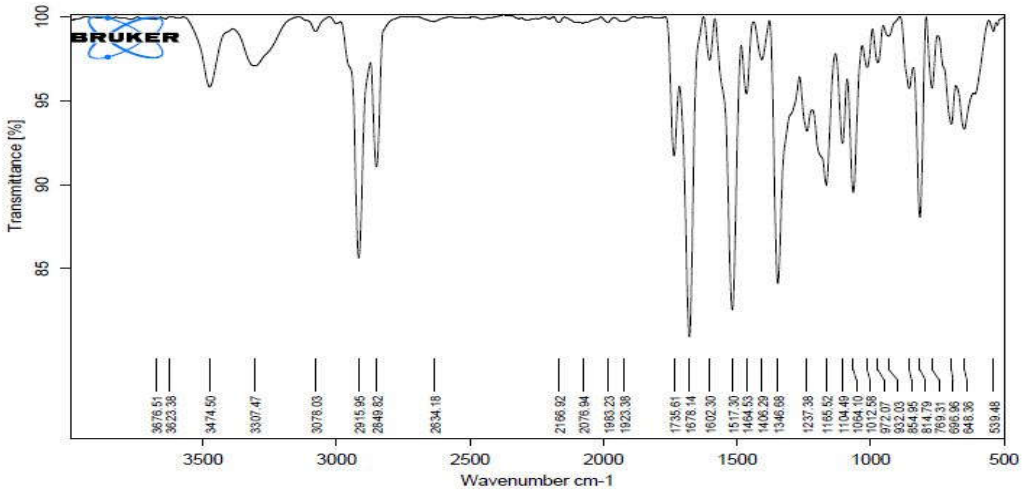

Fig No: 14 FTIR spectra of Gel Formulation.

Table No: 21 Interpretation of FTIR spectra of Gel Formulation.

Functional Group	Standard Range (cm^{-1})	Observed Range (cm^{-1})
R-CH_3	3000-2850	2871
C=C	1680-1600	1602
C-C	1445-1405	1423
COOH	1750-1650	1697
O-H	3500-3200	3470
R-O-R	1300-1175	1288
C≡N	2300-2200	2234
C= N	1790-1690	1697
R- S -R	680-610	662
C-H	2970- 2850	2951

Conclusion:

The formulation and characterization of Chloramphenicol loaded Liposomal Gel have demonstrated promising results on bacterial Meningitis. The developed Liposomal Gel formulation has shown satisfactory physicochemical properties, Particle Size, Entrapment Efficiency, *In- Vitro* Drug Release, indicating its potential as a novel therapeutic approach for the treatment of Bacterial Meningitis.

The F 5, F 7 & F 8 Batches of Chloramphenicol Liposomal Gel were optimized based on evaluation criteria. The optimized batch was characterized for its Particle Size, Entrapment Efficiency, *In-Vitro* Drug Release, pH, Viscosity, % Drug release, Spreadability, Zeta Potential and *Ex- Vivo* Skin Permeation.

The F 7 batch of Liposomal Gel met all physiochemical tests and assessment parameters. It exhibited lower particle size; Higher Entrapment Efficiency & *In-Vitro* Drug Release compared to F 5 & F 8 batches. Among all batches F 7 contains 50mg of chitosan and 20mg Carbopol 934 used as Coating Agent & gelling agent which gives better Particle Size, Entrapment Efficiency, consistency, viscosity and appearance as compare to other batches. Hence, F 7 batch gives significant results and optimized as shown by Particle Size, Entrapment Efficiency, *In- Vitro* Drug Release.

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