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Research Article

Analysing the Release Parameters and Characterisation of Mucoadhesive Non-Selective Beta Blocker Sustained-Release Buccal Films

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Abstract

Timolol Maleate is a non-selective beta-adrenergic blocker, widely used in the treatment of hypertension, however it suffers from limitations such as the need for frequent dosing and extensive first-pass metabolism. This study aims to formulate and evaluate a sustained-release mucoadhesive buccal film containing Timolol Maleate intends to address the existing issues associated with oral administration of this drug. The films were prepared by solvent casting method involving multiple mucoadhesive polymers. These films were evaluated for their physicochemical and mechanical properties to ensure the integrity of the films during handling and drug release profile was examined using *in vitro* drug release and *ex vivo* drug permeation studies. The findings confirmed that the formulation followed Hixson-Crowell release kinetics and achieved a cumulative drug release of approximately 74% over 8 hours. The drug-excipient compatibility was confirmed by FTIR analysis and the thermal behaviour of the drug-loaded films was characterised using DSC, demonstrating a broad endothermic transition with a reduced peak at 211.64°C (onset at 181.42°C); these tests were performed in conjugation with SEM analysis for visualization of surface morphology of the film. Stability studies conducted in accordance with ICH Q1A(R2) guidelines for a period of three months confirmed that there were no significant changes in the physicochemical properties and drug content of the films. Hence, the data supports the potential development of timolol maleate buccal films as a replacement for oral therapy as the films may offer better patient compliance and bioavailability.

Keywords: Timolol Maleate, Buccal Films, Mucoadhesive Polymers, Hypertension

INTRODUCTION

Buccal drug delivery systems represent a significant advancement in the field of pharmacology and therapeutics and a robust alternative, addressing the limitations of conventional oral administration which includes first pass hepatic metabolism leading to decrease in systemic bioavailability, higher and more frequent dosing. Buccal films are thin, flexible dosage forms that adhere to buccal mucosa due to presence of mucoadhesive polymers, which ensures consistent and sustained release of drug. It offers a non-invasive alternative for drugs that are administered by injection, enhancing patient compliance and comfort. This offers a distinct advantage including ease of administration, rapid onset of action, improved patient compliance, and the potential for sustained drug release. The drug is administered via the buccal mucosa which is a highly vascularized region that facilitates rapid and efficient drug absorption. This attribute is particularly beneficial for drugs with low half- life or unstable in the acidic environment.[1]

Timolol Maleate is a non- selective β-adrenergic receptor antagonist elicits antihypertensive effect by inhibiting both β1- and β2-adrenoceptors, culminating in reduced heart rate, decreased cardiac output, and inhibition of renin release from the kidneys. Chemically, it is white to off-white crystalline powder with high aqueous solubility and is widely used in systemic and ophthalmic use.[2] Timolol Maleate exhibits rapid onset of action with a plasma half- life of approximately 4 hours. However, due to extensive first pass hepatic metabolism on oral administration leads to decrease in therapeutic efficiency.[2,3] Initially, it was introduced for the treatment of glaucoma and eventually gained approval for several cardiovascular and neurological indications, which includes hypertension. And hypertension is one of the most prevailing non- communicable diseases and a pioneer cause of morbidity and mortality worldwide.[4]

Recently, Timolol Maleate is commercially available predominantly as oral tablets and ophthalmic solutions. Currently, no buccal films containing Timolol Maleate have been reported in the Indian Pharmaceutical Market. The recent study focuses on the formulation and evaluation of sustained-release mucoadhesive

buccal films of Timolol Maleate using pharmaceutical polymers with the aim of reducing first pass metabolism, dosing frequency and improving patient compliance.[5,6]

MATERIALS AND METHODS

1. Materials and Equipment

1.1 Materials

Timolol Maleate, the active pharmaceutical ingredient, was purchased from Flax Laboratories Pvt. Ltd. in India. Colorcon provided a range of polymers such as hydroxypropyl methylcellulose of various grades, including HPMC K100M, HPMC E15 and Eudragit RS100. Common reagents such as ethanol, methanol, hydrochloric acid, and glycerol were procured from Loba Chemie Pvt. Ltd. in Mumbai, India. S. D. Fine Chemicals Pvt. Ltd. (India) provided buffering agents, such as sodium hydroxide and potassium dihydrogen phosphate and disodium hydrogen phosphate. Analytical reagent grades were used in this study.

1.2 Equipment

The following tools were used for quantitative analysis and characterisation:

Spectroscopic Analysis:

1. Drug content and permeation investigations were conducted using a UV spectrophotometer (V-1900, Shimadzu, Japan). Utilising an FTIR Spectrophotometer (FT/IR-4100 LE, Japan), molecular interactions were examined.

2. Morphological and Thermal Analysis: A Differential Scanning Calorimeter (Mettler Toledo DSC 2) was used to characterise the physical condition and a scanning electron microscope (JSM-6390LV, JEOL, Tokyo, Japan) was used to visualise the surface morphology.

3. Physicochemical Evaluation: An analytical balance (ATY224, Shimadzu, Japan) and a digital vernier calliper (MGW Precision) were used for weighing and measuring the film thickness respectively. A sonicator (Expo-Hitech 8L 200H) and a pH meter (Universal Enterprises, Mumbai) were employed for buffer preparation.

4. General Processing: A magnetic stirrer and water bath shaker (Remi, Mumbai) were used for formulation stirring and temperature-controlled experiments and a hot air oven (Pathak Electrical) was used for drying procedures.

2. Standardization of Timolol Maleate

2.1 Appearance, solubility and melting point

Timolol Maleate was evaluated for its organoleptic properties, including colour, odour and appearance. The solubility of Timolol Maleate was investigated into various solvents like distilled water, ethanol (AR Grade), methanol (AR Grade), isopropyl alcohol (AR Grade), phosphate buffer (pH: 6.8). To determine its melting point, an appropriate amount of Timolol Maleate was placed in a sealed capillary and the melting point was assessed using a Thiele's tube melting point apparatus.[7,8]

2.2 Ultraviolet Spectroscopy (UV)

Analytical method development for Timolol Maleate was performed using the Shimadzu UV-1900i Plus double-beam UV spectrophotometer. Standard stock solutions were prepared in phosphate buffer (pH: 6.8) and methanol (AR Grade). For the calibration curve in the phosphate buffer, a series of dilutions were prepared to achieve a concentration range of 10–50 µg/ mL. The solutions were analyzed at a fixed absorption maximum of 295 nm.[9]

3. Analytical method development of UV spectroscopy method of Timolol Maleate

For analytical method development, the Shimadzu UV-1900i Plus double-beam UV spectrometer was used for analysis of timolol maleate solutions made using phosphate buffer (pH: 6.8) as solvent.

Procedure:

1. 25 mg of Timolol Maleate was accurately weighed on a milligram weighing balance and was transferred into a 25 mL volumetric flask. The volume was made up by using AR grade methanol. The concentration of this stock solution was 1 mg/ mL [1000 ppm].

2. From the above stock solution, 2.5 mL solution was withdrawn and transferred to a 25 mL volumetric flask. The volume was made up using a phosphate buffer of (pH: 6.8). The concentration of this second stock solution was 100 µg/ mL [100 ppm].

3. From the above solution, 1 mL solution was withdrawn and transferred to a 10 mL volumetric flask. The volume was made up with the phosphate buffer (pH: 6.8). The concentration of this third stock solution was 10 µg/ mL [10 ppm].

4. The third stock solution was diluted with a phosphate buffer (pH: 6.8) and five solutions with concentrations ranging from 10-50 µg/ mL were prepared for analysis.

5. These solutions were analysed at a fixed wavelength of 295 nm, and the absorbance was recorded against the phosphate buffer (pH: 6.8) as a blank.

4. Formulation of Timolol Maleate Loaded Buccal Film

Buccal films of Timolol Maleate were formulated using Solvent casting method by using Hydroxypropyl Methylcellulose (HPMC) E15 and HPMC K100M polymers**.** The placebo films were also prepared using the same method, excluding the active constituent.

Accurately weighed quantities of polymers Hydroxypropyl Methylcellulose (HPMC) E15 (750 mg) and HPMC K100M (150 mg) were dispersed in 20 mL of distilled water and stirred continuously using a magnetic stirrer until a clear and uniform polymeric blend was obtained.

In another beaker, the required quantity of Eudragit RS 100 was dispersed and dissolved in 5 ml ethanol and subjected to continuous stirring using a magnetic stirrer until the polymer was completely dissolved. The accurately weighed quantity of Timolol Maleate, was dissolved in 5 mL of ethanol using a vortex mixer to ensure complete solubilization of the active ingredient. This drug solution was slowly added to the Eudragit RS 100 polymer solution with continuous stirring to obtain a uniform mixture.

This polymer-drug mixture was then incorporated into the previously prepared HPMC polymer blend with continuous stirring. Glycerol was incorporated as a plasticizer. The resulting solution was stirred continuously to ensure uniform distribution of all components.

The placebo buccal films were prepared following the same procedure, but without the incorporation of the drug.

The final solution was stirred for an additional 2 hours to achieve complete homogeneity and was then subjected to sonication to remove entrapped air bubbles prior to film casting.[10,11,12]

Table 1: Composition of Placebo buccal film

Placebo Batch Code	HPMC K100M (mg)	HPMC E15(mg)	Eudragit RS100(mg)	Glycerol (mg)	Water: Ethanol
1	150	750	100	120	20:10

Table 2: Composition of Timolol Maleate loaded buccal film

Standard	HPMC K100M (mg)	HPMC E15 (mg)	Eudragit RS100 B (mg)	Glycerol (mg)	Water: Ethanol ratio	Timolol Maleate Drug (mg)
1	150	750	100	120	20:10	162.5

5. Physicochemical and Mechanical Properties of the Buccal Film

5.1 Swelling Index

A digital balance was used to precisely record the buccal film's initial weight. After that, the film was kept at room temperature while submerged in 10 mL of a pH 6.8 phosphate buffer solution. The film was carefully taken out of the buffer after two hours, any extra surface water was gently wiped using filter paper and the final weight was noted.[12] The following formula was used to determine the swelling index:

Swelling Index = (w2-w1)/ (w1)

where,

w2 = Final weight after 2 hrs (mg)

w1 = Initial weight (mg)

5.2 Folding endurance and Thickness

Folding endurance was evaluated manually for each formulation. A strip of the film measuring 2cm × 2cm was repeatedly folded at the same location either until it broke or up to a maximum of 300 folds.[7]

The thickness of the mucoadhesive films was determined using a Digital Vernier calliper with a least count of 0.01 mm. Measurements were taken at ten randomly selected points across the flat surface of each film to ensure uniformity. The thickness was calculated to assess the consistency of the film thickness.[10]

5.3 Surface pH

Surface pH of the buccal film was determined by allowing the buccal film to swell in 5 mL of phosphate buffer (pH 6.8). The surface pH was then measured at regular intervals of 15, 30, and 60 minutes by placing the electrode of a digital pH meter in direct contact with the micro-environment of the swollen film. The measurements were performed in triplicate for each time point and the average pH value was recorded.[12]

5.4 Mucoadhesive Strength

The mucoadhesive strength of the Timolol Maleate buccal film was evaluated using a modified physical balance method. Fresh goat buccal mucosa, washed with phosphate buffer (pH: 6.8) was used as model mucosal membrane. The mucosal tissue was secured onto the lower platform of the apparatus with the mucosal side facing upward. The buccal film was attached to the base of a suspended vial using cyanoacrylate glue and lowered gently to establish contact with the mucosal surface for a predetermined period. Following the contact time, standard weights were added incrementally to the opposing pan of the balance until the film detached from the tissue.[13]

Mucoadhesive strength (g) = Total weight required to detach the formulation.

Force of adhesion (N) = Weight (g) × 9.81/ 1000

6. Drug Content Uniformity

The uniformity of drug content within the polymer matrix was determined using a test sample of dimensions 2 x 2 cm. The test sample was transferred into a test tube containing 10 mL of phosphate buffer (pH 6.8) and then subjected to vortex agitation for 2 hours. The absorbance of the final solution was measured using UV-Visible spectrophotometer and the drug content was calculated using previously established regression equation.[10]

7. In vitro Drug Release Study

The dialysis bag method was used to assess the release profile of Timolol Maleate from the produced buccal film. The dialysis membrane was hydrated before the trial by rinsing it with the release medium after soaking it in distilled water for 12 hours to remove any remaining preservatives. The drug-loaded buccal film was inserted into the dialysis bag, and dialysis clips or thread were used to hermetically seal both ends. After that, the assembly was suspended in a Tarson tube filled with 50 mL of phosphate buffer (pH 6.8) and kept at a physiological temperature of 37 ± 0.5 °C while being continuously stirred magnetically at 50–100 rpm.

At predefined intervals (15 minutes, 30 minutes and 1, 2, 3, 4, 5, 6, 7 and 8 hours), 1 mL aliquots were taken out. Each removed sample was promptly replaced with an equal volume of brand-new, pre-warmed buffers in order to preserve sink conditions. A UV-Visible spectrophotometer with a wavelength of 294 nm was used to measure the amount of the released medication. In order to assess the release kinetics, the percentage cumulative drug release was plotted against time using the obtained data. The data were fitted into a number of mathematical models in order to further clarify the release mechanism.[11,14, 15]

8. Ex vivo Permeation Studies

The *ex vivo* permeation studies were conducted using a modified Franz diffusion cell assembly to evaluate the transmucosal transport of Timolol Maleate. Freshly excised goat buccal mucosa was utilized as the biological membrane, which was securely mounted between the donor and receptor compartments of the diffusion cell. The receptor compartment of the cell was filled with 40 mL of phosphate buffer (pH: 6.8), and the temperature was precisely maintained at 37 ± 0.2°C. Hydrodynamic conditions were sustained through continuous stirring at 50 rpm using a magnetic bead.

A pre-weighed Timolol maleate-loaded buccal film was placed in intimate contact with the mucosal surface, which had been previously moistened with few drops of phosphate buffer (pH 6.8) to simulate physiological conditions. Aliquots of 1 mL were withdrawn from the receptor compartment at predetermined time intervals (15 min, 30 min, and 1, 2, 3, 4, 5, 6, 7, and 8 hours). Following each sampling, an equal volume of fresh, pre-warmed buffer was immediately replenished to maintain sink conditions. The percentage of drug permeated across the mucosal membrane was quantified by measuring absorbance using a UV spectrophotometer at the validated wavelength.[15]

9. FTIR: Drug-Excipient Compatibility Study

The pure drug timolol maleate, excipients and the physical mixture were analysed using the Jasco Fourier transform spectrophotometer (FT/IR-4100 LE, Japan) to evaluate chemical integrity and drug-excipient compatibility within a scanning range of 4000–400 cm^{-1}. [16]

10. Differential Scanning Calorimetry (DSC)

The thermal characteristics and physicochemical state of pure Timolol Maleate and its buccal film formulation were analysed using a Mettler Toledo DSC 2 system. Approximately 2 mg of sample was hermetically sealed in a T-zero aluminium pan and placed in the DSC chamber alongside an empty reference pan. The thermal profiles were recorded over a temperature range of 10°C to 300°C at a constant heating rate of 10.00°C/ min. An inert atmosphere was maintained throughout the analysis by nitrogen gas purged at a flow rate of 50 mL/min. A thermogram was obtained to investigate compatibility of the drug with the excipients.[17]

11. Scanning Electron Microscopy (SEM)

To assess the surface morphology of the films, Scanning Electron Microscopy (SEM) was conducted using a JSM-6390LV Scanning Electron Microscope (JEOL, Tokyo, Japan). Surface topographies were analyzed and photographed via secondary electron imaging at an accelerating voltage of 10 kV.[18]

12. Stability Studies

Following ICH Q1A(R2) guidelines, the stability of the optimized Timolol Maleate buccal film was assessed. For three months, the films were kept at two different temperatures, 25 ± 2°C/ 60 ± 5% RH (ambient) and 5 ± 3°C (refrigerated). The films were taken out and examined for appearance, swelling index in phosphate buffer (pH 6.8) and drug content for three months.[8,9]

RESULTS AND DISCUSSIONS

1. Standardization of Timolol Maleate

1.1 Physicochemical Characterization of Timolol Maleate

Physicochemical characterization of Timolol Maleate (TM) confirmed its identity as a white, crystalline, odourless powder, complying with Indian pharmacopeial standards. The drug exhibited high solubility in distilled water, phosphate buffer (pH 6.8) and AR grade solvents including methanol, ethanol and acetone supporting its suitability for solvent casting method. The melting point of Timolol maleate drug was found to be in the range of 198–205 °C, confirming its purity and crystalline nature.

1.2 UV Spectroscopic Analysis of Timolol Maleate

UV spectroscopic analysis in phosphate buffer (pH: 6.8) showed a distinct absorption maximum (λ_{max}) at 295 nm, which was subsequently used for quantitative analysis throughout the study.

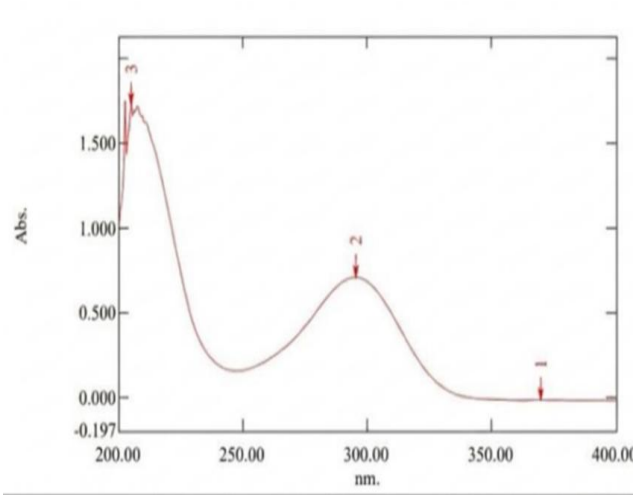

Figure 1: UV Spectra of Timolol Maleate in phosphate buffer pH 6.8

2. Analytical Method Validation

The UV spectrophotometric method developed for Timolol Maleate in phosphate buffer (pH: 6.8) demonstrated excellent linearity in the concentration range of 10–30 µg/ mL, with a regression coefficient (R^2) of 1.0. The linear regression equation (y= 0.0204x + 0.004) confirmed the suitability of the method for accurate drug estimation during formulation evaluation and release studies.

Table 3: Absorbance of Timolol maleate in concentration range 10-30 ppm in Phosphate buffer (pH: 6.8)

Concentration (ppm)	Absorbance
10	0.209
15	0.309
20	0.411
25	0.515
30	0.616

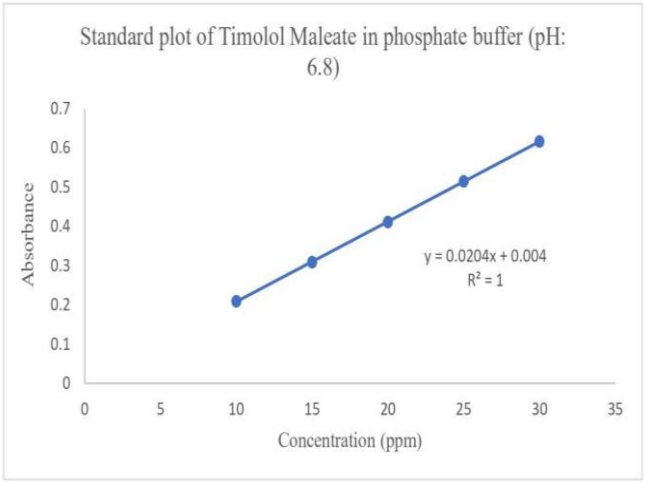

Figure 2: Calibration curve of Timolol Maleate in phosphate buffer (pH 6.8)

3. Formulation of Timolol Maleate (TM) loaded Buccal film

Timolol Maleate loaded buccal films were formulated using polymers such as HPMC E15, HPMC K100M as well as using Glycerol as a plasticizer. As shown, the transparent buccal film was successfully formed by employing the concentration of polymer and plasticizer at room temperature as mentioned in table 1 and table 2.

Figure 3: Buccal film of Timolol Maleate

4. Physicochemical and Mechanical Properties of the Buccal Film

4.1 Swelling Behaviour

For the drug-loaded formulation, the swelling index of the drug-loaded formulation was 6.56 ± 0.33 and that of the placebo formulation was 6.55 ± 0.32. The buffer's entry into the polymeric matrix causes swelling by relaxing and expanding the polymer chains. The swelling behaviour of the Timolol maleate-loaded film was similar to that of the placebo film, suggesting that the drug incorporation did not appreciably change the hydration parameters.[11]

Figure 4: Swelling index of buccal film

4.2 Folding Endurance and Thickness

Folding endurance results suggested elasticity and resistance to cracking, indicating that the film had sufficient mechanical integrity and flexibility to endure handling and application. For the prepared batch, the folding endurance of the Timolol maleate-loaded film was 452 ± 3.00 and 451 ± 3.00 for the placebo film.

The thickness of the drug-loaded film and placebo film was found to be 0.137 ± 0.004 mm. Hence, incorporation of the drug did not alter the film thickness when compared to the placebo. The measured thickness of the Timolol maleate-loaded film remained within the acceptable range for buccal administration, ensuring both patient comfort and uniform drug release.[11]

Figure 5: Measurement of thickness of the buccal film

4.3 Surface pH

The mean surface pH for placebo films was 6.54 ± 0.28 and for Timolol maleate loaded films, it was 6.38 ± 0.22. The values closely correspond to the physiological pH of buccal mucosa. This indicates that the film is therefore unlikely to cause mucosal irritation, making it suitable for prolonged buccal residence.

4.4 Mucoadhesive Strength

The adhesion of the film is primarily mediated by hydrogen bonding and physical entanglement between the hydrophilic polymer chains and the mucin of the buccal mucosa, ensuring sufficient residence time for drug absorption.

Table 4: Mucoadhesion strength

Timolol maleate buccal film	Mucoadhesion strength (g)				Force of Mucoadhesion (N)
	1	2	3	Average	0.376
	35	40	40	38.33 ± 2.89	

Figure 6: Mucoadhesion Testing using a Modified Physical Balance

5. Drug Content Uniformity

The optimised Timolol maleate loaded buccal film demonstrated a drug content of 93.2 ± 1.45 %. This high level of content uniformity confirms the reliability of the formulation process and ensures consistent dose delivery within the polymeric matrix.

6. *In Vitro* Release

Timolol maleate has a sustained release profile for eight hours, according to *in vitro* drug release experiments. The development of a hydrated polymeric gel layer that controls drug diffusion is responsible for the regulated release. A diffusion-controlled process typical of hydrophilic matrix systems was confirmed by regression analysis, which revealed that the release matched the Hixson-Crowell model (R^2 = 0.9873).

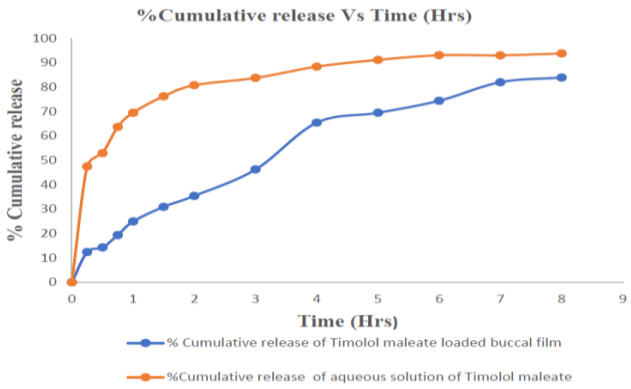

Figure 7: Cumulative drug release (%) versus time (Hrs)

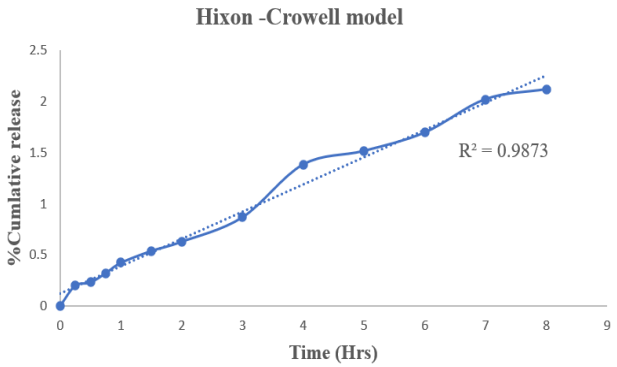

Figure 8: Hixson-Crowell release kinetics of optimized Timolol Maleate buccal film

7. *Ex Vivo* Permeation

Ex-vivo permeation studies using goat buccal mucosa as the model mucus membrane demonstrated gradual transmucosal transport of Timolol maleate. The results show a cumulative drug release of approximately 74% over 8 hours, suggesting that the buccal route may be used to successfully bypass hepatic first-pass metabolism.

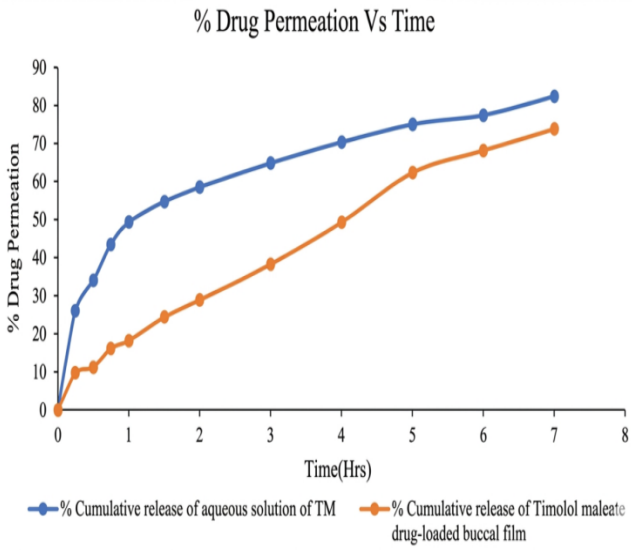

Figure 9: % Drug Permeation Vs Time (Hrs)

8. FTIR Spectroscopic Analysis

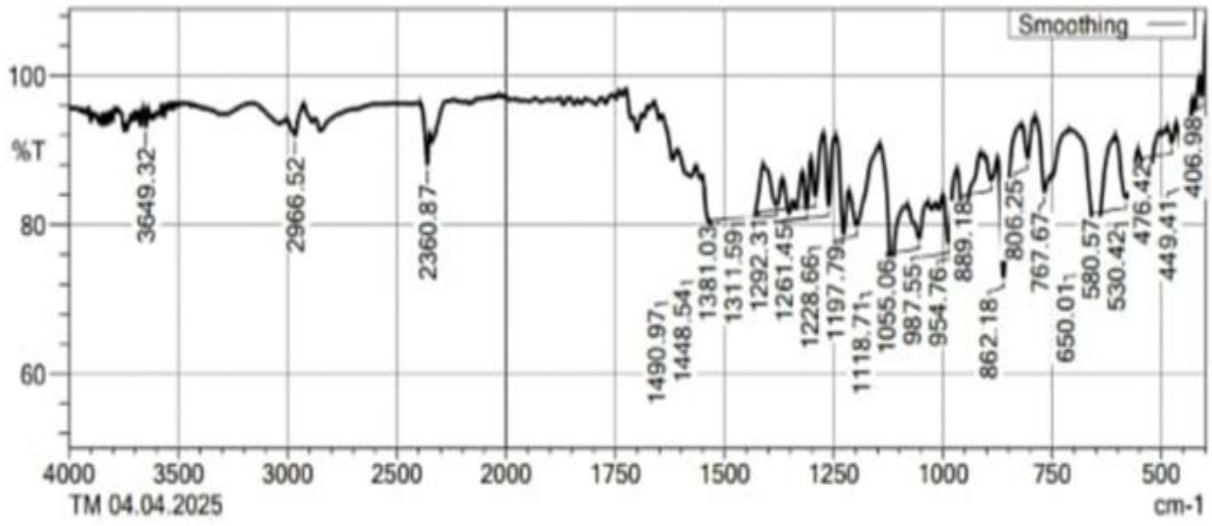

Figure 10: FTIR Spectra of Timolol Maleate

Table 5: Characteristic Peaks and Wavenumber of Timolol Maleate

Characteristic Peaks	Observed Wavenumber (cm^{-1})	Wavenumber range (cm^{-1})
O-H stretch	3649.32	3300-3500
N-H stretch	3037.89	3300-3500
C=O stretch	1753.29	1740-1720
N-S stretch	889.18	910-900
C-H Stretch	2966.52	2960
C-O stretch	1292.31	1100-1200

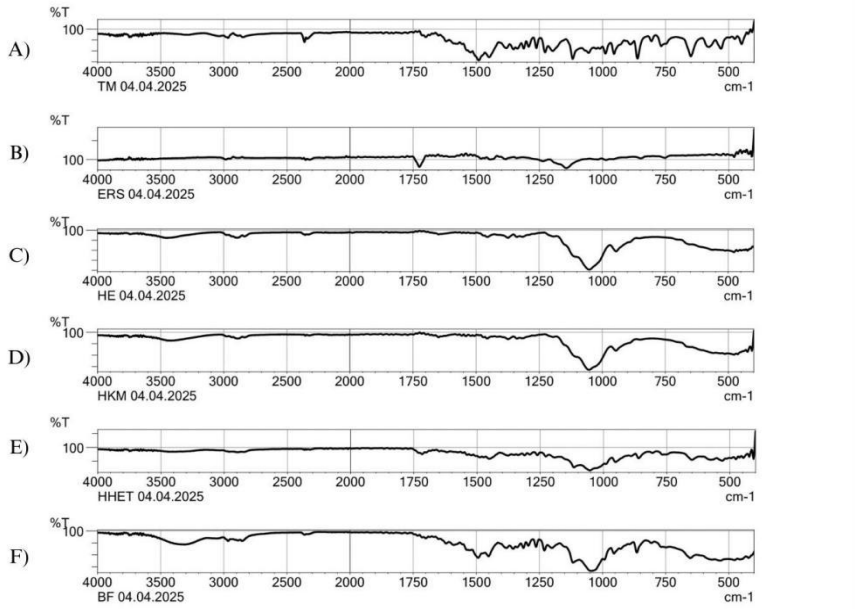

Figure 11: FTIR Spectra of: A) Timolol Maleate (TM), B) Eudragit RS100 (ERS), C) HPMC E15 (HE), D) HPMC K100M (HKM), E) HPMC E15 HPMC K100M Eudragit RS100 Timolol Maleate physical mixture (HHET) and F) Blank Film (BF)

As shown in Figure 11, the physical mixture (HHET) retains all major peaks of timolol maleate and the polymers without significant shifts, indicating a lack of chemical interaction. Though they exhibited slight broadening and reduced intensity, the absence of new peak formation or the disappearance of existing peaks confirms that Timolol Maleate and the excipients are chemically compatible and that no interactions occurred during the film preparation process.

9. Differential Scanning Calorimetry (DSC)

Figure 12 represents the thermogram of pure Timolol Maleate showing a sharp endothermic peak at its melting point 202.53°C (onset at 200.67°C), the sharp peak confirms the drug's crystalline nature. Conversely, a broad endothermic transition with a reduced peak at 211.64°C (onset at 181.42°C) for Timolol Maleate loaded buccal film can be seen in Figure 13. This suggests a partial conversion of the drug to its amorphous state.

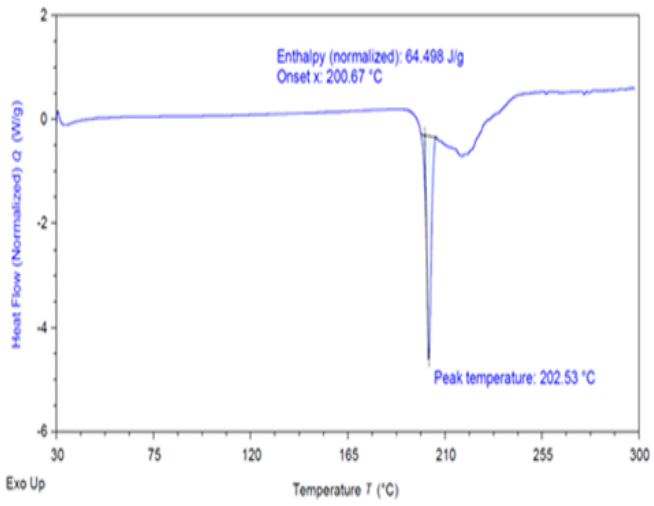

Figure 12: DSC of Timolol Maleate

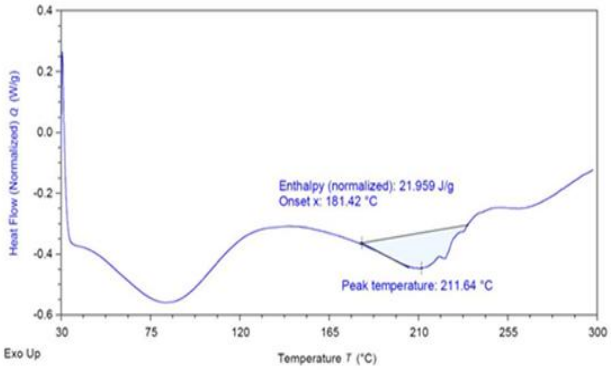

Figure 13: DSC of Timolol Maleate loaded buccal film.

10. Scanning Electron Microscopy (SEM)

Figure 14 depicts the placebo buccal film, exhibiting a smooth, uniform and continuous surface. The following images in Figure 15 show a Timolol Maleate loaded buccal film having homogenous surface with uniform dispersion of drug and no visible agglomerates, minor variations on the surface could be attributed to incorporation of drug.

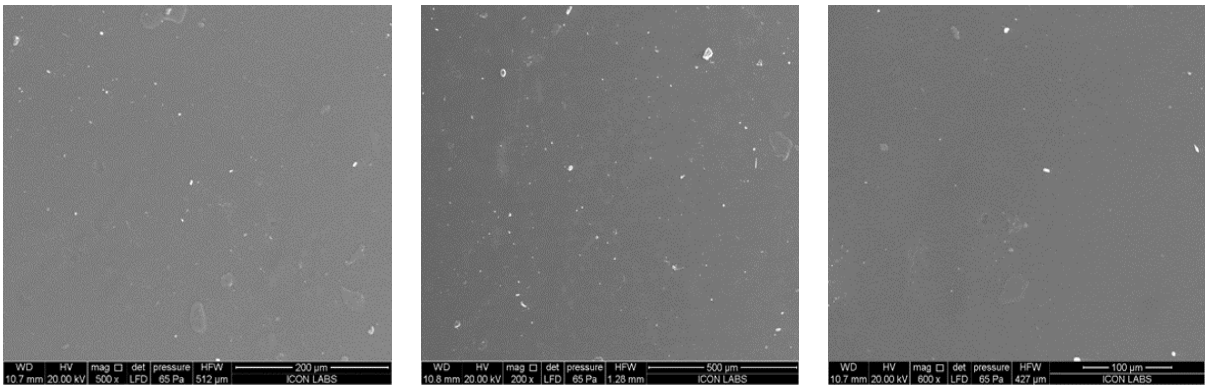

Figure 14: Scanning Electron Microscope images of Placebo buccal film

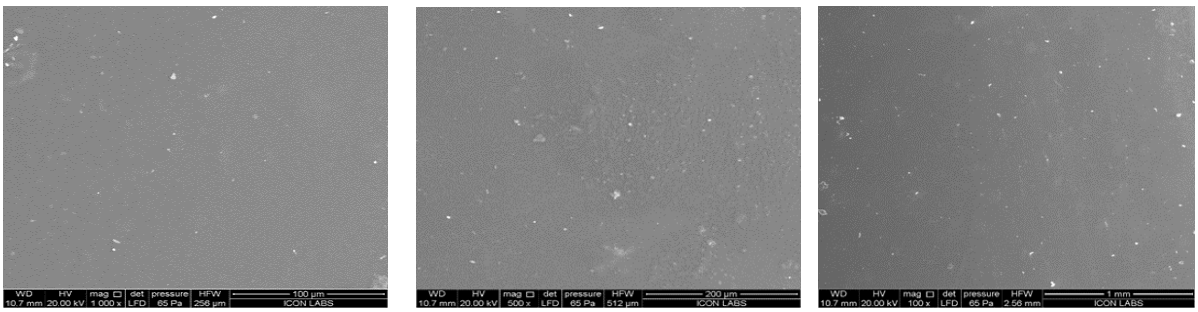

Figure 15: Scanning Electron Microscope images of Timolol Maleate loaded buccal film

11. Stability Studies

The stability of the drug loaded buccal film was tested in accordance with ICH Q1A(R2) guidelines. As shown in Table 6, no significant changes were seen in the appearance, swelling index or drug content of the film over a period of 3 months. Hence, these findings indicate that the buccal film remains stable in both ambient and refrigerated conditions.

Table 6: Stability Studies for Timolol Maleate Buccal Film

Parameters	1 month		2 months		3 months	
	5 ± 3°C	25 ± 2°C/ 60±5%RH	5 ± 3°C	25 ± 2°C/ 60±5%RH	5 ± 3°C	25 ± 2°C/ 60±5%RH
Appearance	Opaque	Opaque	Opaque	Opaque	Opaque	Opaque
Swelling index in Phosphate buffer (pH 6.8)	7.5	6.9	7.3	7.8	7.4	6.8
Total drug content (%)	94.57 %	93.2%	95.34%	93.78%	93.25%	90.02%

CONCLUSION

The buccal films of Timolol Maleate can be prepared successfully by the combination of HPMC K100M, HPMC E15 and Eudragit RS100 for sustained drug delivery. The formulation showed favourable mechanical strength, mucoadhesive properties and drug release control making it an adequate substitute for conventional oral dosage forms. The *in vitro* dissolution profile showed sustained release of Timolol Maleate from the buccal film over a period of 8 hrs which indicates that the polymers are suitable for this purpose. Hence, the study observed that the buccal films of Timolol Maleate reduced the first-pass metabolism via buccal route in the management of hypertension.

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