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A Study On Controlled Porosity Osmotic Tablet Of Propanolol Hydrochloride With Its Formulation And Characterization To Enhance Its Therapeutic Efficacy And Improve Patient Compliance.

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ABSTRACT

OBJECTIVE

The aim of this study was to formulate and characterize controlled porosity osmotic tablet of propanolol hydrochloride for oral administration having compressed tablet core coated with a semi-permeable membrane covering.

MATERIALS AND METHOD

The selected drug Propanolol Hydrochloride was used for formulating osmotic tablet. In preformulation study of Propanolol Hydrochloride drug was studied by using physicochemical characteristics of the pharmacological material, such as solubility, polymorphism, and particle size, are revealed through pre-formulation investigations. This knowledge aids in the formulation of acceptable dose forms, the choice of appropriate excipients, and the optimisation of the drug release and bioavailability.

RESULTS AND DISCUSSION

In order to distribute medications in a regulated and predictable manner, controlled porosity osmotic tablets (CPOTs) combine the concepts of controlled release with osmotic pressure. These tablets generally consist of an osmotic agent- and drug-filled core encircled by a semi-permeable membrane. The results of evaluation parameters such as weight variation, hardness, friability, disintegration test for tablets, in vitro dissolution study indicated that prepared tablets under the acceptable range.

CONCLUSION

This study highlighted the significance of brand-new, controlled porosity osmotic tablet of propanolol hydrochloride.

INTRODUCTION

Drug delivery systems do play a significant part in providing the best possible products for currently available drugs, whether in terms of better or more effective drug presentation to the systemic circulation. The earliest studies into the topic of regulated medicine distribution started in the 1950s. Other pharmaceutical drugs with controlled release characteristics have since been created. The startling increase could be attributed to the several advantages these products provide, such as improved treatment efficacy, increased patient compliance, potential cost savings, patentability, and the potential to lengthen product lifecycle.

Advantages of controlled drug delivery

Comparing controlled drug delivery systems to traditional immediate-release formulations, there are a number of benefits. The following are some major benefits of regulated medication delivery:

1. **Enhanced Therapeutic Efficacy**: Optimised medication distribution is made possible by controlled drug delivery systems, which enhances therapeutic effectiveness. [3]

2. **Improved Patient Compliance**: Comparing controlled medication delivery systems to traditional formulations, less frequent dosage is frequently necessary. Patients will feel less burdened as a result, and the medication schedule will be easier to follow. [4]

3. **Reduced Side Effects**: Systematic medication distribution can reduce the negative effects brought on by varying drug dosages.[5]

4. **Prolonged Drug Action**: They can maintain medication release for a longer time, resulting in a longer-lasting therapeutic impact. [6]

5. **Targeted Delivery:** Specific bodily areas might be the focus of controlled medication delivery systems.[7]

6. **Reduced Frequency of Administration**: The frequency of medicine administration can be decreased with controlled drug delivery devices. [8]

7. **Improved Safety Profile**: Controlled drug delivery systems can raise the safety profile of drugs by reducing the likelihood of dose dumping or overdosing.[9]

8. **Tailored Release Profiles**: Release profiles can be changed to create continuous, pulsatile, or focused release, enabling different treatment modalities.[10]

9. **Better Pharmacokinetic Control**: The exact regulation of medication release rates and plasma concentrations is made possible by controlled drug delivery systems. [11]

10. **Optimization of Drug Formulations**: To achieve desired release kinetics, stability, and compatibility, they enable the integration of various drug carriers, excipients, and release-modifying agents.[12]

Oral Controlled Drug Delivery Systems

Oral controlled release systems continue to hold the bulk of the market share among the multiple controlled release (CR) drug delivery systems that are now available. This is likely due to its apparent advantages of ease of administration and greater patient compliance.[13] The bulk of oral CR dosage formulations fall into the following categories:

1. **Matrix Systems:** Diffusion-controlled systems, sometimes referred to as matrix systems, include spreading or embedding the medication within a matrix or solid polymer. The matrix, which serves as a reservoir for the medication, has an even distribution of the drug throughout it. Given that the medication must diffuse through the matrix in order to reach the surface for release, matrix systems provide sustained release over a prolonged length of time.[14,15]
2. **Reservoir Systems:** A drug reservoir is contained within a rate-regulating membrane or coating in reservoir systems. By diffusing through the membrane, eroding or dissolving the membrane, or both, the medication is released from the reservoir system. By altering the membrane characteristics, reservoir systems can enable controlled release over an extended period of time and offer greater flexibility in controlling the release rate.[16,17]
3. **Osmotic Systems**: The driving force behind medication release in osmotic systems, commonly referred to as osmotic-controlled release systems (OCRS), is osmotic pressure. Osmotic systems may be made for continuous or pulsatile medication release and give constant release rates.[18]

Novel drug delivery systems (NDDS)

The development of innovative drug delivery systems (NDDS) is the primary focus of pharmaceutical research and development. While simultaneously developing NDDS for innovative treatments, the purpose of NDDS is to boost the commercial viability of currently available pharmaceuticals.[19]

Osmotically controlled drug delivery, which employs osmotic pressure as a driving mechanism for regulated dispersion of active medicines, is one of the most promising drug delivery techniques. Drug release from osmotic systems is independent of pH and hydrodynamic conditions of the body because of the semi-permeable nature of the rate-controlling membrane and the design of the delivery orifice used in them, resulting in a high degree of in vitro/in vivo correlation. There are several osmotic pumps for various drugs on the market to accommodate patients' needs. [20]

Introduction to controlled porosity osmotic tablet (CPOT)

The area of drug delivery systems has a long history with the idea of osmotic pressure-based medication release. Here is a quick synopsis of its history:

1. **Early Development**: Osmosis as a method of medication administration has been around since the 1950s. The development of osmotic pumps, which used a mechanical mechanism to regulate drug delivery, was the main emphasis in the early years. These early pumps were based on the osmosis concept, but instead of using hydrostatic pressure created by osmotic inflow, they depended on external forces for drug expulsion.[21]

2. **Introduction of Osmotic Tablets**: Osmotic tablets were first proposed as a more sophisticated method of osmotic medication administration in the 1970s. The production of controlled porosity osmotic tablets (CPOTs) was made possible by the discovery of cellulose acetate-based semi-permeable membranes and improvements in tablet formulation technology.[22]

3. **Advancements in Membrane Technology**: Semi-permeable membranes, which are employed in osmotic drug delivery systems, have seen major developments throughout time. Researchers looked into a variety of membrane materials, including polymeric substances like polyethylene glycol, polyvinyl alcohol, and ethylcellulose, as well as cellulose acetate, cellulose acetate butyrate, and cellulose acetate butyrate. These developments attempted to increase biocompatibility, regulate membrane porosity, and increase membrane permeability.[23]

4. **Formulation Optimization**: The formulation of osmotic pills has undergone much research and development. Researchers focused on the selection and optimisation of osmotic agents, excipients, and drug formulations to achieve desired medicine release patterns. Examining formulation variables such

osmotic agent concentration, tablet size, and shape allowed for the regulation of medicine release rates and the achievement of peak performance.[24]

5. **Diversification of Applications**: Numerous therapeutic fields have found use for osmotic pressure-based medication release. When regulated and sustained medication release is needed, the technique has been used to create extended-release formulations. Osmotic systems have also been used for chronotherapy, site-specific medication administration, and targeted drug delivery.[25]

6. **Current and Future Trends:** Utilising innovative materials, such as stimuli-responsive polymers, has recently become possible in osmotic drug delivery in order to enable triggered or on-demand release. Additionally, initiatives are being undertaken to increase the adaptability and flexibility of osmotic systems by including several drug compartments or release mechanisms.[26]

The regulated and predictable release of medications over a lengthy period of time is the goal of controlled porosity osmotic tablets (CPOTs), a particular kind of drug delivery device. These tablets were especially designed to control the release of medications using the concepts of osmosis and porous membranes. CPOTs are frequently employed to maximise medication treatment, provide longer therapeutic benefits, lower frequency of dose, and increase patient compliance.[27]

Osmotic pressure-based drug release

Osmosis, or the transport of solvent molecules over a semi-permeable membrane from an area of lower solute concentration to an area of greater solute concentration, is the core idea of CPOTs. In CPOTs, the medicine is released as a result of the osmotic pressure produced by the solution inside the tablet core. The semi-permeable membrane allows water to pass through, creating a hydrostatic pressure that causes the medicine to be released from the tablet.[28]

Controlled porosity membrane

The semi-permeable membrane employed in CPOTs is essential for regulating the rate of drug release. Due to the unique properties of this membrane, water may flow through whereas the medication or other solutes cannot do so directly. It functions as a barrier to limit the flow of water into the tablet core, preserving osmotic pressure and enabling carefully timed medication release. The pace and duration of medication release may be controlled by varying the membrane's porosity and thickness.[29]

Design considerations

A number of things must be carefully taken into account while designing CPOTs. The formulation must balance the membrane permeability, medication release rate, and fundamental characteristics of the tablet. To achieve the appropriate release properties, different excipients, including osmotic agents, pore-forming agents,

and plasticizers, may be added to the tablet core. Drug release kinetics are also influenced by the material of the semi-permeable membrane and its characteristics, such as pore size, permeability, and thickness.[30]

Mechanism of drug release

Osmotic inflow and water uptake are involved in the drug release process in CPOTs. Water seeps through the semi-permeable membrane as the tablet comes into touch with biological fluids, propelled by the osmotic pressure produced by the solute concentration within the core. This inflow of water causes a medication solution or suspension to develop inside the tablet. A regulated push of the medication solution via a tiny delivery aperture as it builds up results in a prolonged and reliable drug release.[31]

Advantages of CPOTs

CPOTs provide a number of benefits over traditional medication delivery methods. As a result of the precise control they offer over drug release kinetics, prolonged release formulations that maintain therapeutic drug concentrations for a long time may be created. By lowering the number of doses required, CPOTs can increase patient comfort and compliance. Additionally, they can lessen variations in medication concentration, enhancing therapeutic results and minimising unwanted effects.[32]

Examples of CPOT applications

To meet certain medication delivery objectives, CPOTs have been used in a variety of therapeutic contexts. They have been used to deliver medications with a longer duration of action in extended release formulations. The use of CPOTs for site-specific or targeted drug delivery enables localised drug release at the desired place in the body. Examples include the administration of analgesics, diabetes medications, and anti-hypertensive medications.[33]

Current trends and upcoming directions: With continuing research and development projects aimed at expanding its capabilities, CPOT technology is still being developed. The introduction of innovative membrane materials, including biodegradable polymers, has recently advanced biocompatibility and decreased the requirement for removal following drug administration.[34]

MATERIALS AND METHOD

Propranolol Hydrochloride was obtained from Fisher Scientific, PEG 400, Mannitol Triethyl citrate, Hydroxypropyl methylcellulose (HPMC), microcrystalline cellulose, Sodium starch glycolate, Magnesium stearate, n-octonol was obtained from Sigma-Aldrich and Other chemicals used were of analytical grade.

INSTRUMENTS USED

SOXHLET, Centrifuge, Electric heater, Digital pH meter, Optical microscope, Zetasizer was of Duran Group, Refrigerator, Digital balance, Magnetic stirrer, Dissolution Apparatus, Graduated cylinder, Volumetric pipette, Test tubes was of Mettler.

PREFORMULATION STUDIES

Preformulation is described as a phase of research and development process, where the physicochemical properties of the drug substances and the excipients used are characterized in order to achieve success in developing a stable formulation.

PHYSICAL APPEARANCE

Drug	Propranolol hydrochloride
Chemical formula	C16H22ClNO2
Solubility	Practically insoluble in ether, benzene, ethyl acetate
Molecular Weight	295.80
Color	White or almost white powder
Appearance	Solid
Odor	Odorless
Taste	Bitter
Melting Point	163-164 °C
Stability/Shelf Life	IT IS STABLE TO HEAT, UNSTABLE TO LIGHT.

Melting point method

Propranolol hydrochloride's melting point may be found using a standard approach called the melting point method. Here is a broad description of how the melting point calculation is carried out:

Sample Preparation: Obtain a tiny quantity of propranolol hydrochloride, making that it is crystalline or finely powdered. The sample needs to be dry and impurity-free.

Melting Point Apparatus: A Mel-Temp device or a capillary tube melting point apparatus should be set up as an appropriate melting point equipment. The equipment normally consists of a magnifying glass or a microscope, a heating block or hot plate, and a thermometer.

Capillary Tube Filling: The sample of propranolol hydrochloride should be put into a capillary tube. Using a spatula or other suitable filling tool, the sample is placed into the capillary tube's open end, which has one end capped. Make sure the sample is well sealed and devoid of air bubbles.

Melting Point Determination: Make sure the sealed end of the capillary tube is placed closer to the heat source as you insert it into the melting point device. Heat the sample slowly and steadily while keeping a close eye on it under the microscope or a magnifying glass. The melting point range is the range of temperatures at which the sample begins to liquefy and full melting takes place.

Recording the Melting Point: Note the range of temperatures at which the sample melts. The range of the melting point, from the temperature at which the first evidence of melting is seen to the temperature at which total melting occurs, is how the melting point is commonly stated.

Determination of flow properties of pure drug

Bulk density

The mass of a powder or granular substance per unit volume, including the interstitial spaces between the particles, is referred to as bulk density. Propranolol hydrochloride is one of the powdered drugs that it is used to characterise. The bulk density can reveal details about the material's packing and flow characteristics.

To determine the bulk density of Propranolol hydrochloride, the following procedure can be followed:

Sample Preparation: Ensure that the Propranolol hydrochloride sample is finely powdered and free from any lumps or aggregates. It is important to use a representative sample for accurate results.

Bulk Density Apparatus: Use a graduated cylinder or a bulk density apparatus specifically designed for measuring bulk density. The apparatus usually consists of a measuring container with a known volume.

Bulk Density Measurement: Fill the measuring container with the Propranolol hydrochloride sample, taking care to avoid compaction. Level off the top of the sample using a straight-edge or spatula. Record the mass (m1) of the sample in grams.

Volume Measurement: Measure the volume (V) occupied by the Propranolol hydrochloride sample in the measuring container. This can be done by noting the initial and final volume readings on the graduated cylinder or by using the volume measurement function of the bulk density apparatus. Calculate the bulk density (ρ) using the formula:

Bulk density= Mass of powder/volume of powder

Tapped density

Another crucial factor used to describe the packing and flow characteristics of powdered compounds, including propranolol hydrochloride, is tapped density. It is a measurement of the density attained when tapping or compaction is used to remove spaces and settle the particles in a powder.

To determine the tapped density of Propranolol hydrochloride, the following procedure can be followed:

Sample Preparation: Prepare a representative sample of Propranolol hydrochloride, ensuring it is finely powdered and free from any lumps or aggregates.

Tapped Density Apparatus: Use a tapped density apparatus, which typically consists of a graduated cylinder or a measuring vessel, a mechanical tapper, and a timer.

Tapped Density Measurement: Fill the measuring vessel with the Propranolol hydrochloride sample to a predetermined initial volume. The initial volume should be sufficient to allow for compaction during tapping. Record the mass (m1) of the sample in grams.

Tapping Procedure: Start the tapping apparatus and allow it to tap the sample for a specified number of taps. The tapping frequency and duration may vary depending on the specific method or instrument being used. Common tapping frequencies range from 250 to 300 taps per minute.

Volume Measurement: After the specified number of taps, measure the final volume (V) of the sample in the measuring vessel. This can be done by noting the initial and final volume readings on the graduated cylinder or using the volume measurement function of the tapped density apparatus. Tapped density was calculated by the formula

$$\text{Tapped density} = \text{Mass of powder}/\text{Tapped volume}$$

Compressibility index and Hausner ratio

Compressibility index and Hausner ratio are two parameters used to assess the flowability and compressibility characteristics of powdered materials, including Propranolol hydrochloride:

Compressibility Index (Carr's Index): Compressibility index is a measure of the compressibility or bulk density variation of a powder. It is calculated using the following formula:

$$\text{Carr's index} = TD-BD/TD\times100$$

Where,

TD=Tapped density

BD=Bulk density

The compressibility index indicates the powder's propensity to undergo volume reduction upon compaction. Higher values of compressibility index suggest poor flowability and higher compressibility of the powder.

Generally, a compressibility index below 15% indicates good flowability, while values above 25% indicate poor flow properties.

Hausner Ratio

Hausner ratio is another parameter used to evaluate the flowability and compressibility of powders. It is calculated by dividing the tapped density of the powder by the bulk density:

Hausner ratio= TD/BD

The Hausner ratio provides an indication of the ease with which the powder flows. A higher Hausner ratio suggests poorer flow properties.

Typically, a Hausner ratio below 1.25 is considered indicative of good flowability, while values above 1.5 indicate poorer flow properties.

Angle of repose

The angle of repose is a parameter used to assess the flowability and cohesiveness of a powdered or granular material, including Propranolol hydrochloride. It represents the maximum angle at which a heap of the material remains stable without flowing or sliding. The angle of repose is influenced by factors such as particle size, shape, density, and interparticle friction.

To determine the angle of repose of Propranolol hydrochloride, the following procedure can be followed:

Sample Preparation: Ensure that the Propranolol hydrochloride sample is dry and free-flowing. Remove any clumps or aggregates and ensure a uniform particle size distribution.

Setup: Place a funnel or a cylindrical container with a defined diameter (D) and height (H) on a flat, horizontal surface. Make sure the surface is free from any vibrations.

Pouring the Powder: Gradually pour the Propranolol hydrochloride sample through the funnel or gently from a measuring cylinder onto the center of the base. Allow the powder to form a conical heap naturally.

Determining the Angle: After the heap has settled, measure the height (h) and the radius (r) of the cone formed by the powder. The radius can be measured from the center of the base to the outer edge of the heap. Calculate the tangent of the angle of repose (θ) using the formula:

$$\mathbf{Tan\ \theta = h/r}$$

Where,

h= height of pile (cm)

r= radius of pile (cm)

The angle of repose can provide valuable information about the flowability and handling characteristics of Propranolol hydrochloride. A smaller angle of repose indicates better flowability and lower cohesion, while a larger angle suggests poorer flow properties and higher cohesion.

PREPARATION OF OSMOTIC PUMP TABLETS

Material Preparation:

Propranolol hydrochloride: Weigh and accurately measure the required quantity of Propranolol hydrochloride as per the desired dosage strength.

Excipients: Prepare the excipients required for the granulation process, including binders, fillers, disintegrants, lubricants, and any other necessary excipients. Measure and accurately weigh them according to the formulation.

Granulation

Mixing: In a suitable mixing vessel, blend the Propranolol hydrochloride with the excipients using a mechanical blender. Continue blending until a uniform mixture is obtained.

Wet Granulation: Add a suitable binder solution (e.g., polyvinylpyrrolidone solution or hydroxypropyl cellulose solution) to the mixture gradually while mixing. Continue blending until the mixture forms wet granules with the desired consistency. Adjust the binder solution quantity as needed to achieve proper granulation.

Core Tablet Preparation:

Drug Layer: Formulate a drug layer containing Propranolol hydrochloride as the active ingredient along with other excipients such as binders, disintegrants, and fillers. The excipients should be selected to ensure drug stability and appropriate release characteristics.

Push Layer: Prepare a push layer that consists of osmotic agents, such as sodium chloride, and swelling agents like hydrophilic polymers. The push layer generates osmotic pressure, which drives drug release.

Coating Preparation:

Semipermeable Membrane: Prepare a coating solution of a semipermeable membrane-forming polymer, such as cellulose acetate or cellulose acetate butyrate, in an appropriate solvent. The concentration of the polymer should be optimized for the desired release rate.

Coating Process: Apply the semipermeable membrane coating onto the core tablets using a suitable coating apparatus like a pan coater or fluidized bed coater. Ensure uniform and complete coating of the tablets.

Drying and Finishing:

Drying: Dry the coated and laser-drilled tablets in a suitable drying chamber or oven to remove any residual solvent and ensure proper coating adhesion.

Finishing: Conduct a visual inspection of the dried tablets for quality, ensuring that they are free from defects or damage. Package the finished osmotic pump tablets in suitable packaging material to maintain their stability and protect them from environmental factors.

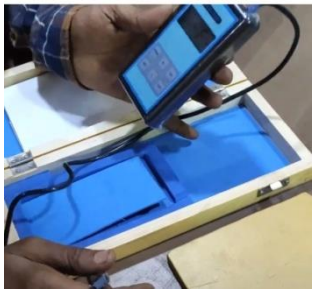
S.no	Ingredients	TABLET-1	TABLET-2	TABLET-3	TABLET-4
1.	Propranolol hydrochloride	300	300	300	300
2.	Microcrystalline cellulose	25	30	20	20
3.	Hydroxypropyl methylcellulose (HPMC)	95	90	100	95
4.	Sodium starch glycolate	75	70	70	80
5.	Magnesium stearate	15	10	10	05

Table: Composition of osmotic pump Propranolol hydrochloride tablets(mg)

EVALUATION OF CONTROLLED POROSITY OSMOTIC PUMP TABLETS

Thickness

Vernier callipers (Mitutoyo Corp., Japan) are used to measure the thickness of individual tablets because they provide an accurate thickness measurement in millimetres. Each tablet's maximum thickness variation is 5%.



Measurement of coat thickness

The film was separated from the tablets after dissolving, and it was dried at 40°C for one hour. Using electronic digital callipers (Mitutoyo Corp., Japan), thickness was measured, and mean values were taken.

Friability

In a Roche friabilator (Sisco, India), tablets were friable. Twenty tablets of known weight (W0) were de-dusted in a plastic friabilator chamber at a set speed of 25 rpm for four minutes, and the weights of the tablets were then reweighed. The following equation was used to compute the percentage of friability:

$$\text{Friability} = (1 - \frac{W}{Wo}) \, x \, 100$$

Where, W0 and W are the weight of the tablets before and after the test respectively.

Weight variation test

For the weight variation test, 20 tablets are individually weighed, the average weight is calculated, and the individual tablet weights are compared to the average. Calculating the % weight difference and comparing it to USP requirements.

In-vitro dissolution release of Propranolol hydrochloride

Propranolol hydrochloride was released in vitro from prepared tablets at a rate of 1.2 HCL for two hours and a rate of phosphate buffer pH 6.8 for the following hours. The investigations were conducted using the USP Dissolution Apparatus II (Dissolution Test Apparatus, Electrolab, India), which operates at a temperature and speed of 37 0.5 °C and 50 rpm. Using a UV spectrophotometer, samples were taken out every hour and tested for the presence of propranolol hydrochloride at 207 nm for pH 1.2 acid buffers and 206 nm for pH 6.8 phosphate buffers.

Uniformity of drug content test

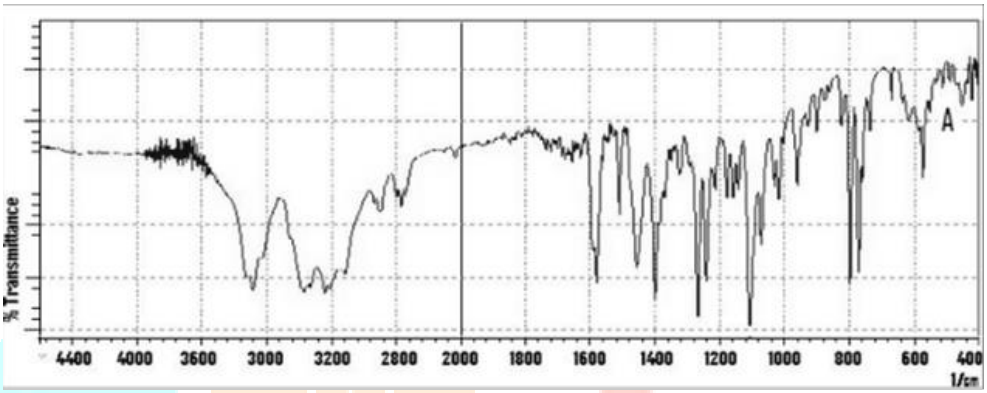
Ten CPOP formulation pills from each batch were removed and ground into powder using a triturator. One tablet's worth of powder was dissolved using a magnetic stirrer for 24 hours in a volumetric flask filled with 100 ml of 0.1N HCl. The solution was diluted appropriately, filtered using Whatman Filter Paper No. 1, and then spectrophotometrically analysed. Size of the tablet Vernier callipers (Mitutoyo Corp., Japan) are used to measure the diameter of individual tablets, providing a precise measurement in millimetres.

RESULT & DISCUSSION

In order to distribute medications in a regulated and predictable manner, controlled porosity osmotic tablets (CPOTs) combine the concepts of controlled release with osmotic pressure. These tablets generally consist of an osmotic agent- and drug-filled core encircled by a semi-permeable membrane. The active pharmaceutical ingredient (API) may be released steadily and predictably over an extended period of time thanks to CPOTs, which offer fine control over drug release kinetics. Drugs that need a consistent blood concentration for the best therapeutic effects might benefit notably from this controlled release profile. CPOTs can lessen the frequency of dosing by offering a regulated release of the medication. As a result, patients might only need to take a smaller number of pills throughout the day, which can increase compliance and convenience. The controlled release profile that CPOTs are able to accomplish can contribute to long-term maintenance of the medication concentration within the targeted therapeutic range.

Preformulation studies

In the current study, we evaluated some of the physiochemical properties of propranolol hydrochloride as well as our goal of developing analytical methodologies for it. Propranolol hydrochloride was shown to have the maximum solubility in methanol, and all conventional graphs were demonstrated to be linear. Since propranolol hydrochloride is crystalline and hydrophobic, it requires granules to create solid dosage forms due to its poor flowability.



FTIR spectrum of Propranolol HCl

The Flow properties of pure drug

The bulk density of Propranolol hydrochloride was measured to be 0.39 g/mL. Bulk density represents the mass of the powder divided by its bulk volume. Tapped density, which refers to the density of the powder after it has been subjected to tapping or vibration to achieve a more compact packing, was determined to be 0.50 g/mL. Carr's index, calculated as (Tapped density - Bulk density) / Tapped density × 100, was found to be approximately 22%. Husnar's ratio, determined by dividing the tapped density by the bulk density, was measured to be approximately 1.28. The angle of repose, an important parameter to assess the flowability and cohesion of the powder, was found to be 16.6 degrees.

These flow property measurements offer important information for the design and production of dosage forms based on propranolol hydrochloride. Understanding and improving the drug's flow characteristics can assist to guarantee the consistency, processability, and performance of the finished product.

The Flow properties of pure drug was calculated and reported in Table below:

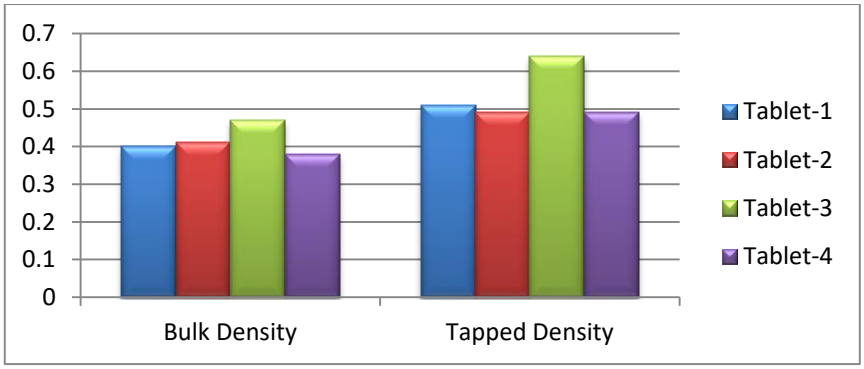
S.No	Flow Properties	Propranolol hydrochloride
1.	Bulk Density	0.39 gm/ml
2.	Tapped Density	0.50 gm/ml
3.	% Carr's Index	22%
4.	Husnar's Ratio	1.28
5.	Angle of Repose	16.6^{o}

Pre compression parameters of formulated tablets

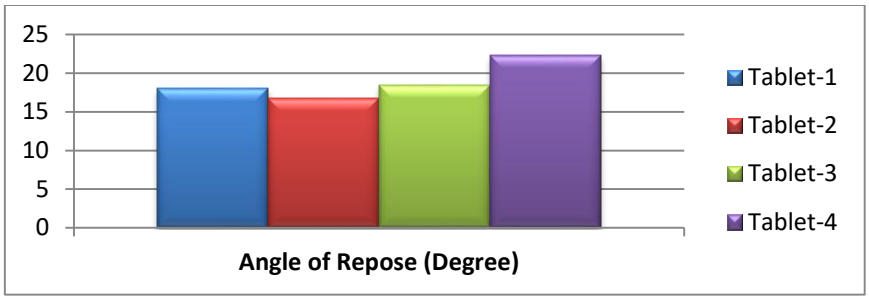
All the compressible excipients for various batches were evaluated for angle of repose, bulk density, tapped density, Carr's index and Hausner's Ratio.

S.No	Bulk Properties	Tablet -1	Tablet -2	Tablet -3	Tablet -4
1.	Bulk Density	0.40	0.41	0.47	0.38
2.	Tapped Density	0.51	0.49	0.64	0.49
3.	% Carr's Index	21.57%	16.33%	26.56%	22.45%
4.	Husnar's Ratio	1.275	1.195	1.362	1.289
5.	Angle of Repose	18^{o}	16.8^{o}	18.5^{o}	22.25^{o}

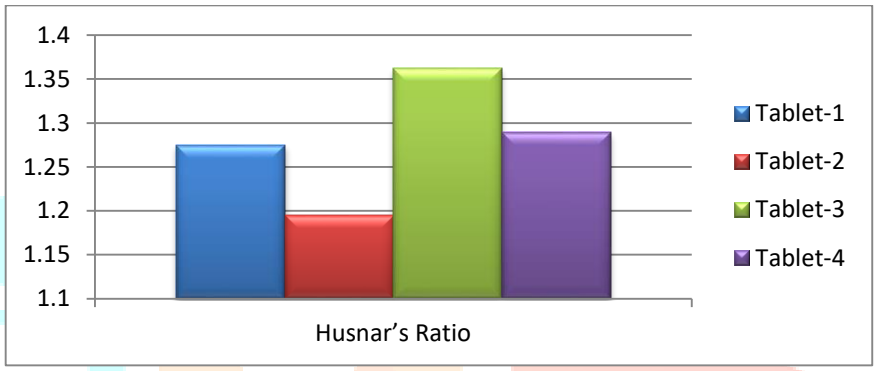
Graph of Tablets (Bulk density and Tappped density)



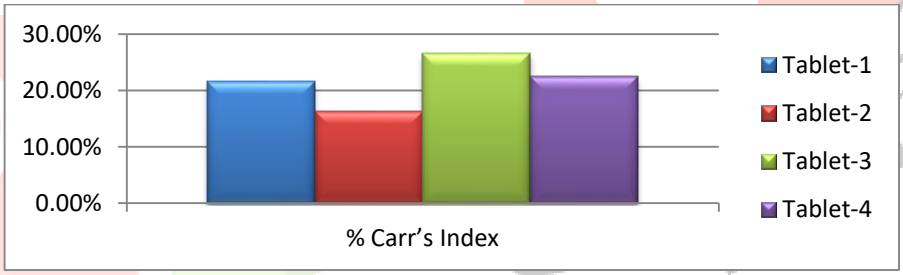
Tablets were evaluated for Angle of repose



Tablets were evaluated for Hausner's Ratio



Tablets were evaluated for Carr's index

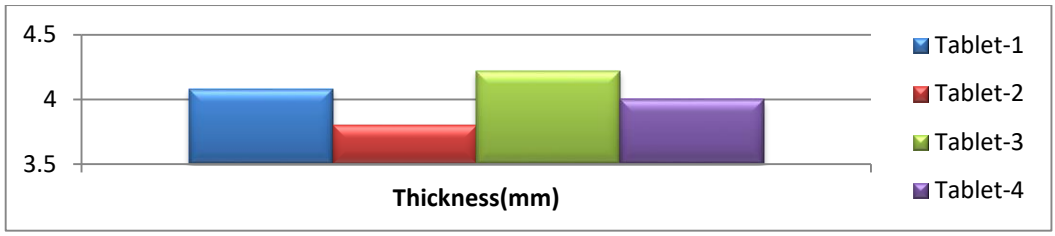


Post compression parameters

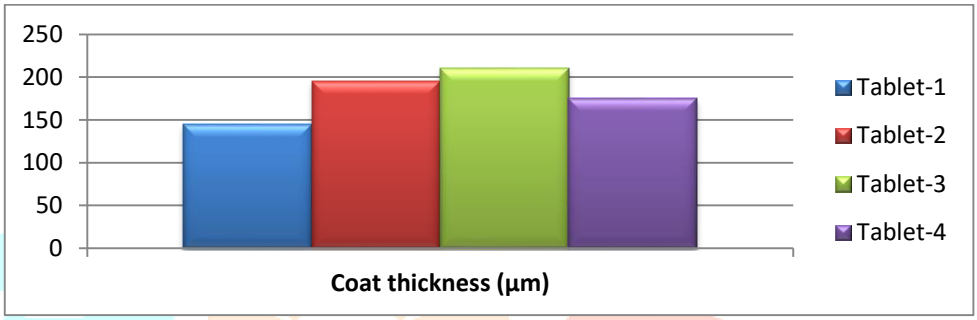
All the post compression parameters for various Tablets evaluated accordingly such as thickness, coat thickness, hardness, friability, weight variation and diameter of tablet etc.

S.No	Bulk Properties	Tablet -1	Tablet -2	Tablet -3	Tablet -4
1.	Thickness(mm)	4.08	3.80	4.22	4.0
2.	Coat thickness (µm)	145.5	195.5	210.55	175.50
3.	Hardness (kg/cm^2)	5.6	5.5	5.8	5.7
4.	Friability %	0.36	0.42	0.39	0.36
5.	Average weight of tablet (mg)	505	502	505	498
6.	Diameter (mm)	11.14	11.55	11.45	11.54

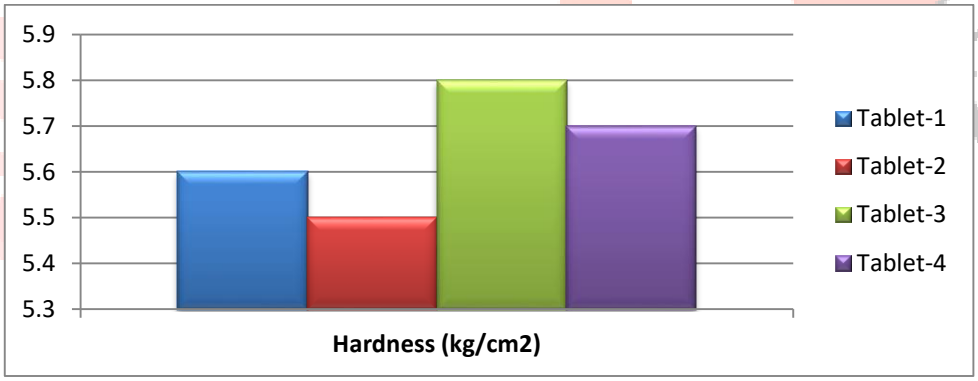
Post compression parameters for various Tablets evaluated accordingly such as thickness, coat thickness, hardness, friability, weight variation, drug content and diameter of tablet



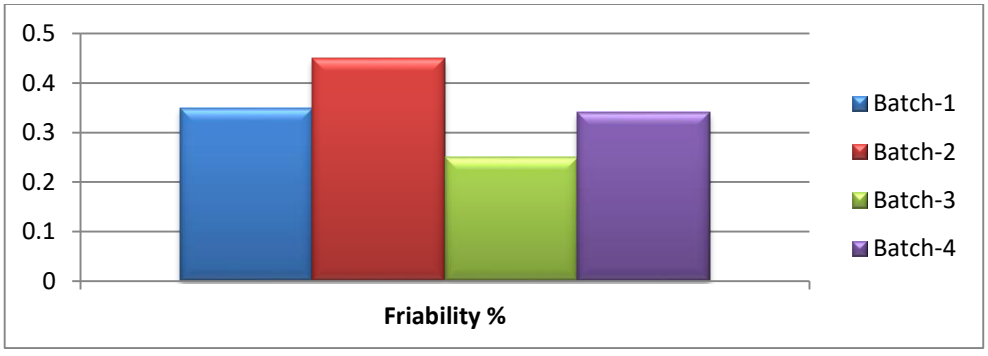
Post compression parameters for various Tablets evaluated accordingly such as, coat thickness



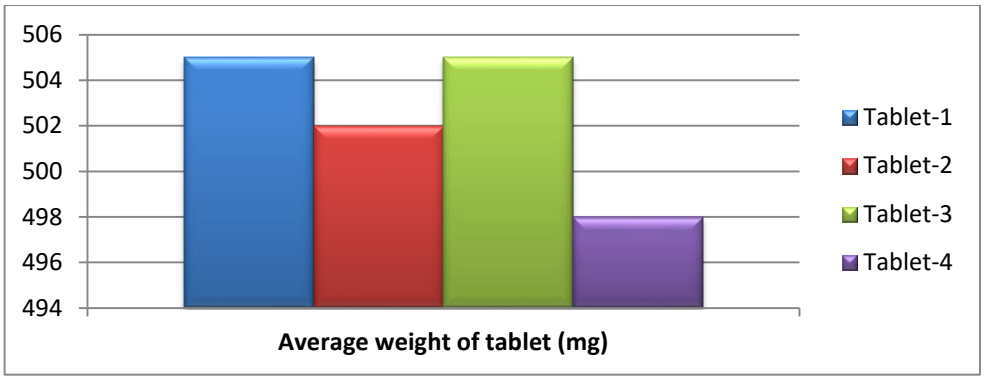
Post compression parameters for various Tablets evaluated accordingly such as hardness, friability, weight variation, drug content and diameter of tablet



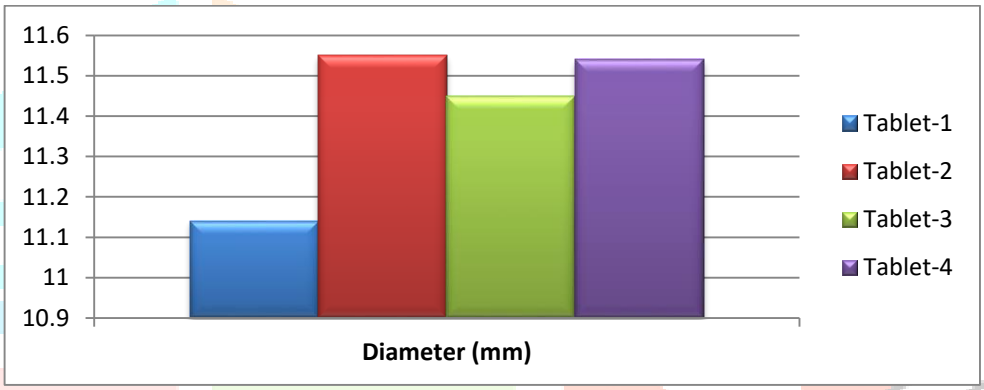
Post compression parameters for various Tablets evaluated accordingly such as friability, weight variation, drug content and diameter of tablet



Post compression parameters for various Tablets evaluated accordingly such as, weight variation, drug content and diameter of tablet



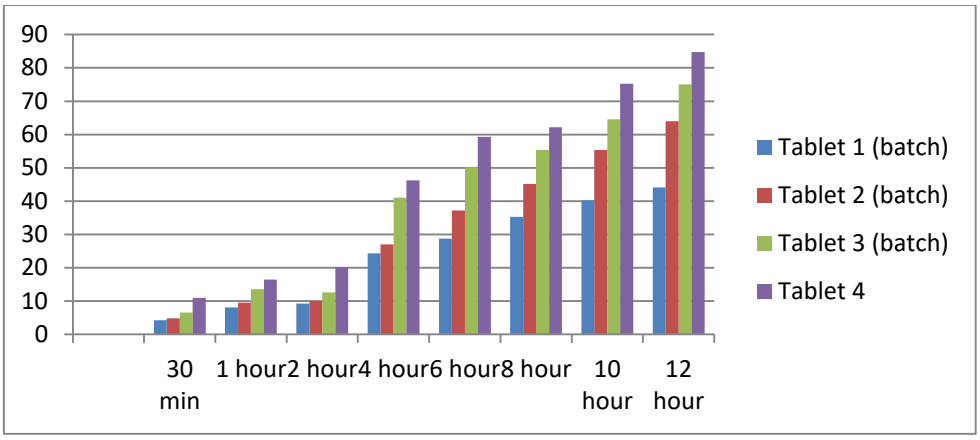
Post compression parameters for various Tablets evaluated accordingly such as diameter of tablet



Dissolution study of extended release matrix tablet of Propranolol hydrochloride (Cumalative % drug release)

Time	Tablet 1 (batch)	Tablet 2 (batch)	Tablet 3 (batch)	Tablet 4 (batch)
30 min	4.25	4.85	6.58	11.02
1 hour	8.12	9.50	13.62	16.42
2 hour	09.25	10.06	12.65	20.25
4 hour	24.35	27.02	41.05	46.25
6 hour	28.75	37.25	50.13	59.32
8 hour	35.24	45.20	55.34	62.15
10 hour	40.25	55.34	64.56	75.25
12 hour	44.15	64.03	75.06	84.71

Graph of Cumulative Percent drug release



SUMMARY AND CONCLUSION

We summarized these points from study:

Propranolol hydrochloride is stated to have a melting point between 163 and 166°C, showing the range of temperatures at which it changes from a solid to a liquid form. Additionally, propranolol hydrochloride is renowned for being odourless, which is beneficial for pharmaceutical compositions when sensory qualities are taken into account. Propranolol hydrochloride has a partition coefficient of around 1.8, which is a value. Its intermediate affinity for both lipids and water is indicated by this coefficient, which was calculated in the context of the octanol/water system. Propranolol HCl's FTIR spectra showed distinctive peaks that corresponded to several functional groups.

The Flow properties of pure drug

Bulk Density: The bulk density of Propranolol hydrochloride powder was determined to be 0.39 g/mL.

Tapped Density: The tapped density, achieved after subjecting the powder to tapping or vibration to achieve a more compact packing, was found to be 0.50 g/mL.

Carr's Index: A Carr's index of 22% suggests moderate flowability for Propranolol hydrochloride.

Husnar's Ratio: The Husnar's ratio, determined by dividing the tapped density by the bulk density, was measured to be approximately 1.28. A Husnar's ratio of 1.28 indicates reasonable flowability for Propranolol hydrochloride.

Angle of Repose: The angle of repose, which represents the maximum angle formed between the surface of a pile of powder and the horizontal plane, was found to be 16.6 degrees.

Pre compression parameters of formulated tablets

Bulk density of 0.40 g/mL, while its tapped density was measured to be 0.51 g/mL. The Carr's index, which indicates flowability, was calculated to be 21.57%. The Husnar's ratio, a measure of flowability, was determined to be 1.275. The angle of repose, which reflects the powder's flowability and cohesion, was found to be 18°.

The bulk density was recorded as 0.41 g/mL, while the tapped density was 0.49 g/mL. The Carr's index was measured to be 16.33%, suggesting good flowability. The Husnar's ratio indicated reasonable flow properties at 1.195. The angle of repose was determined to be 16.8°, indicating favorable flow characteristics.

In the case of Tablet-3, the bulk density was found to be 0.47 g/mL, while the tapped density was measured at 0.64 g/mL. The Carr's index was relatively high at 26.56%, indicating reduced flowability. The Husnar's ratio was calculated as 1.362, suggesting somewhat compromised flow properties. The angle of repose was recorded as 18.5°.

Lastly, Tablet-4 demonstrated a bulk density of 0.38 g/mL and a tapped density of 0.49 g/mL. The Carr's index was determined to be 22.45%, indicating moderate flowability. The Husnar's ratio was approximately 1.289, suggesting acceptable flow properties. The angle of repose was measured to be 22.25°, indicating relatively lower flowability and cohesion.

Post compression parameters

Tablet-1 exhibited a thickness of 4.08 mm, with a coat thickness of 145.5 µm. The tablet hardness was measured to be 5.6 kg/cm2, and the friability percentage was found to be 0.36%. The average weight of Tablet-1 was recorded as 505 mg, with a diameter of 11.14 mm.For Tablet-2, the thickness was measured as 3.80 mm, while the coat thickness was determined to be 195.5 µm. The tablet hardness was reported as 5.5 kg/cm2, and the friability percentage was 0.42%. The average weight of Tablet-2 was noted as 502 mg, with a diameter of 11.55 mm.

In the case of Tablet-3, the thickness was found to be 4.22 mm, with a coat thickness of 210.55 µm. The tablet hardness was recorded as 5.8 kg/cm2, and the friability percentage was observed to be 0.39%. The average weight of Tablet-3 was calculated as 505 mg, and the tablet diameter was measured as 11.45 mm.

Lastly, Tablet-4 demonstrated a thickness of 4.0 mm, with a coat thickness of 175.50 µm. The tablet hardness was determined to be 5.7 kg/cm2, and the friability percentage was found to be 0.36%. The average weight of Tablet-4 was reported as 498 mg, and the tablet diameter was recorded as 11.54 mm.

Further research is needed to investigate the solubility and release profile of the tablets. Although the current study provided valuable insights into the post-compression parameters and bulk properties of the tablets, understanding the solubility behavior and release kinetics is crucial for evaluating their effectiveness in delivering the drug.

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