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Research Paper

Fiber Optics Analysis of Floating Hollow Microspheres for a Poorly Water-Soluble Drug

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Abstract:
This study investigates the development and evaluation of floating hollow microspheres for the delivery of omeprazole, a poorly water-soluble drug. The research aims to enhance omeprazole's bioavailability by addressing its low solubility and susceptibility to degradation in an acidic gastric environment. Hollow ethyl cellulose microspheres encapsulating omeprazole were prepared using the solvent evaporation technique. The microspheres displayed 91.3% buoyancy and 82.41% drug entrapment efficiency, with sustained drug release in simulated gastric fluid over 12 hours. Characterization techniques such as X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM) were used. XRD analysis indicated that the encapsulated drug was in an amorphous state, improving dissolution rates and bioavailability. FTIR confirmed successful drug encapsulation, and SEM revealed the morphology and porous structure of the microspheres. The results highlighting the potential of floating hollow microspheres to enhance the oral bioavailability of poorly water-soluble drugs. Recommendations include refining the formulation process and exploring microfluidic technology for generating uniform microspheres with high drug loading. The study provides valuable insights for the development of advanced drug delivery systems.

Keywords: *omeprazole, hollow microsphere, buoyancy, encapsulation, fiber optics*

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I. Introduction:

Oral drug administration is preferred due to its non-invasiveness, patient compliance, and convenience of drug administration.[1] Oral drug bioavailability is influenced by factors such as drug solubility, permeability, stability, gut microbiota, nanoparticle properties, molecular characteristics, dosage form design, and physiological conditions like diet, age, and liver disease.[2] Gastric emptying in turn affects the absorbance of a drug via the stomach. Therefore, floating drug delivery systems prolong gastric residence time, improve bioavailability, and provide controlled drug delivery by remaining buoyant in the stomach.[3] However, a significant challenge arises when dealing with poorly water-soluble drugs, which often exhibit compromised bioavailability and erratic absorption profiles.

Omeprazole, a proton pump inhibitor extensively used for managing gastroesophageal reflux disease and peptic ulcers, typifies such drugs.[4] Omeprazole's poor water solubility and instability in acidic conditions lead to low bioavailability, although co-administration with certain drugs or under specific conditions may mitigate this issue.[5] Several strategies have been looked into for improving the bioavailability of poorly water-soluble drugs through nanoparticles, liposomes, solid dispersions, emulsions, dispersion techniques, and supercritical antisolvent techniques.[6-8] Among these, the development of floating drug delivery systems has garnered considerable attention. Floating drug delivery systems prolong gastric residence time, improve bioavailability, and enhance solubility for drugs with narrow absorption windows and low solubility at high pH values.[3,9] This is particularly advantageous for drugs like omeprazole, which are primarily absorbed from these regions.

One innovative approach within this area is the preparation of floating hollow microspheres. These microspheres, also known as microballoons, offer several benefits, such as enhanced buoyancy, controlled and sustained drug release, and improved drug stability in the gastric environment.[10-12] By encapsulating the drug in

a porous, hollow structure, these microspheres can float on gastric fluids, providing a prolonged gastric residence time and thereby enhancing the bioavailability of the drug. Various research efforts have shown the promise of floating hollow microspheres in addressing the delivery challenges posed by poorly soluble drugs. For example, studies on drugs like famotidine and celecoxib have demonstrated improved bioavailability and therapeutic efficacy when delivered via floating microspheres.[13-14] These encouraging outcomes highlight the potential of such systems for other poorly soluble drugs, sparking interest in further investigation and optimization.

Despite the potential benefits, the formulation of effective floating microspheres is fraught with challenges, such as achieving optimal drug entrapment efficiency, maintaining the structural integrity of microspheres, and ensuring a sustained and predictable drug release profile. Previous research has explored different methodologies, including solvent evaporation and drop-by-drop techniques, utilizing various polymers to enhance the performance of these drug delivery systems.[15-16] In light of these developments, the objective of this study is to develop and evaluate ethyl cellulose-based floating hollow microspheres encapsulating omeprazole. This approach aims not only to improve the bioavailability and therapeutic efficacy of omeprazole but also to provide valuable insights into the formulation strategies applicable to other poorly water-soluble drugs. By addressing key parameters such as buoyancy, drug entrapment efficiency, in vitro drug release, and structural characterization through advanced analytical techniques, this study aspires to contribute significantly to the field of pharmaceutical drug delivery systems.

II. Material and Methods:

Materials: Omeprazole, which was gifted by the National Pharmaceutical Industries of Oman. Ethylcellulose (50 cps); dichloromethane, methanol, polyvinyl alcohol of analytical grades were used. Double distilled water was used throughout the experiment.

Methods:

Preparation of omeprazole hollow microsphere

The hollow microspheres were prepared using the solvent evaporation technique. The process was used two phases: in phase one, 50 mg of omeprazole is dissolved in 25 ml of methanol, while in phase two, 100 mg of ethyl cellulose is dissolved in 25 ml of dichloromethane (DCM). The solution of phase one was then dissolved in the polymer slurry from phase two using the drop-by-drop method. This solution was then transformed into an oil-in-water emulsion by adding it drop by drop into an aqueous phase containing 0.1% polyvinyl alcohol solution and span 80 at 40°C. The organic solvent was evaporated through continuous stirring for 1 hour, forming a cavity that made the microspheres hollow. The resulting microspheres were collected by filtration and subsequently washed multiple times with distilled water to eliminate any residual solvent or unencapsulated drug. Finally, the washed microspheres were transferred to a rotary evaporator operating at 260 rpm at 44°C. The resulting microspheres were left to dry at room temperature before being collected for evaluation. Throughout the process, parameters such as stirring speed, solvent evaporation rate, and drug-to-polymer ratio were meticulously controlled to achieve the desired size, morphology, and drug encapsulation efficiency of the microspheres.

Preparation of Calibration curve:

To develop the calibration curve for the quantification of omeprazole in the floating hollow microspheres, a series of standard omeprazole solutions with known concentrations were prepared. For this, one liter of phosphate buffer (pH 7.4) was prepared. A stock solution was made with a concentration of 100 mg/100 ml or 1 mg/ml, resulting in a concentration of 1000 µg/ml. Aliquots of stock solutions were then prepared at concentrations of 2 µg/ml, 4 µg/ml, 6 µg/ml, 8 µg/ml, and 10 µg/ml. Finally, the fiber optics probes were placed in the aliquots to measure the absorbance at 304.8 nm. The absorbance values obtained from these standard solutions were plotted against their respective concentrations to generate the calibration curve.

Percentage Yield

The percentage yield of the floating hollow microspheres was calculated to quantify the efficiency of the solvent evaporation technique employed in the preparation process. After the completion of microsphere formation, the microspheres were collected, washed with distilled water to remove any residual solvent or unreacted materials, and then dried at room temperature. The dried microspheres were then weighed accurately using an analytical balance. The percentage yield was determined by comparing the total weight of the dried microspheres to the initial weight of the raw materials (drug and polymers) used in the formulation process. The formula applied was:

% yield = (Weight of the microspheres/Weight of the polymer + drug) x 100 (1)

Drug Entrapment Efficiency

To determine the drug entrapment efficiency of the floating hollow microspheres encapsulating omeprazole, an accurately weighed sample of the drug-loaded microspheres (around 100 mg) was taken and transferred to a 100 mL volumetric flask. Methanol was added to dissolve the encapsulated drug completely, and the solution was sonicated for 10 minutes to ensure comprehensive dissolution of omeprazole. The resulting solution was filtered using a 0.45 µm membrane filter to remove any undissolved particles or polymer residues. The filtrate was then diluted appropriately with methanol for spectrophotometric analysis. The concentration of omeprazole in the diluted solution was measured using fiber optics at 304.8 nm, with a calibration curve of pure omeprazole in methanol serving to determine the concentration from the absorbance values. The drug entrapment efficiency (DEE) was calculated using the formula:

DEE % = (Practical drug content / Theoretical drug content) × 100 (2)

where practical drug content refers to the amount of drug quantified in the microspheres via spectrophotometry, and theoretical drug content is the total amount of drug initially used in the preparation.

Buoyancy studies

The buoyancy studies for the floating hollow microspheres were conducted to evaluate their floating capabilities in simulated gastric fluid. The microspheres were introduced into a beaker (100mL) containing 0.1N hydrochloric acid (pH 1.2) at 37°C ± 0.5°C to simulate gastric conditions. An initial weight of the microspheres (0.1 g) was recorded before they were gently placed in the fluid, which was agitated for 3 hours. Observations were made over a specified period, typically ranging from a few minutes up to several hours, to monitor the floating behavior and duration. Microspheres that floated on the surface were periodically assessed, considering the percentage of microspheres remaining buoyant and the duration of their flotation. This was calculated by comparing the weight of the floating microspheres to the total weight initially introduced. The percentage buoyancy was calculated using the formula:

% Buoyancy = (Weight of floating microspheres/Initial weight of microspheres) x 100 (3)

Scanning Electron Microscopy (SEM)

The morphological characterization of the floating hollow microspheres was carried out using SEM (Jeol, Tokyo, Japan). To prepare the samples for SEM analysis, the microspheres were gently collected and placed on an aluminum stub using double-sided adhesive carbon tape. Excessive microspheres were carefully blown away using a gentle stream of nitrogen gas to prevent aggregation and to ensure a clear view of individual microspheres. Subsequently, the samples were coated with a thin layer of gold using a sputter coater to enhance conductivity and prevent charging under the electron beam. The sputter-coating process was conducted under vacuum conditions, maintaining a coating thickness of approximately 10 nm to ensure uniform coverage without obscuring fine surface details. The coated samples were then placed in the SEM chamber and examined using an accelerating voltage of 15 kV to obtain detailed micrographs. The SEM images were captured at varying magnifications to observe the overall morphology, surface topology, and hollow core structure of the microspheres. These images provided critical insights into the structural integrity and spherical nature of the microspheres, verifying their physical attributes necessary for efficient drug delivery.

X-Ray Diffraction (XRD)

The XRD analysis was conducted to investigate the crystalline nature and phase composition of the omeprazole-loaded floating hollow microspheres. This method aimed to determine whether the encapsulation process had affected the crystalline state of omeprazole, which plays a critical role in its dissolution and bioavailability. XRD analysis was performed using a Panalytical X'Pert pro X-ray diffractometer (Malvern Pananlytical, USA) equipped with a Cu Kα radiation source (λ = 1.5406 Å). A small quantity of the dried microspheres was gently pressed onto a glass sample holder to form a smooth and even surface layer. Care was

taken to ensure that the sample was evenly distributed on the holder to avoid preferential orientation effects. The diffraction patterns were recorded over a 2θ range of 10° to 70°. A step size of 0.02° 2θ, and the scanning speed was maintained at 2° per minute.

Diffraction patterns were recorded, and the intensity of diffracted X-rays was measured as a function of the incident angle. The obtained XRD patterns were compared to standard reference patterns in the Joint Committee on Powder Diffraction Standards (JCPDS) database to identify the crystalline phases present within the microspheres. Peaks in the diffraction pattern corresponding to crystalline omeprazole were analyzed. The presence or absence of characteristic diffraction peaks was used to determine the crystalline or amorphous state of the encapsulated drug. The broadening of peaks and the presence of diffuse scattering were also analyzed to assess the amorphous content of the Omeprazole within the microspheres.

Fourier-Transform Infrared (FTIR) Spectroscopy

FTIR spectroscopy was employed to confirm the successful encapsulation of omeprazole within the ethyl cellulose microspheres and to identify any potential chemical interactions between the drug and the polymer. The FTIR analysis was conducted by grounding a small amount of each sample (approximately 2-5 mg) and then mixing it with potassium bromide (KBr) powder in a 1:100 ratio. The mixture was then compressed into a thin, transparent pellet using a hydraulic press under high pressure. The KBr pellets containing the samples were placed into the sample holder of the FTIR spectrometer (Bruker, USA). The FTIR spectra were recorded in the wavelength range of 4000 cm^{-1} to 400 cm^{-1} at a resolution of 4 cm^{-1}. Each spectrum was obtained by averaging 32 scans to ensure a high signal-to-noise ratio. The obtained spectra for pure Omeprazole, ethyl cellulose, and the drug-loaded microspheres were analyzed and compared. Characteristic peaks corresponding to functional groups of Omeprazole and ethyl cellulose were identified. Any shifts in peak positions or changes in intensity were noted to assess potential interactions between the drug and polymer.

In-Vitro Drug Release

To evaluate the in-vitro drug release behavior of omeprazole-loaded floating hollow microspheres, the dissolution study was conducted using a USP Type II (paddle) dissolution apparatus. Simulated gastric fluid (SGF) without enzymes was prepared, comprising 0.1 N hydrochloric acid (HCl), mimicking the gastric conditions, with a pH of 1.2. An accurately weighed quantity of floating hollow microspheres equivalent to 20 mg of omeprazole was introduced into 900 ml of the dissolution medium maintained at 37 ± 0.5°C. The paddle speed was set to 50 revolutions per minute (rpm) to ensure proper agitation and mimic gastric motility. At predetermined time intervals (0.5, 1, 2, 4, 6, 8, and 12 hours), a fiber optics probe was introduced in the dissolution medium and analyzed at 304.8 nm.

III. Results and Discussion

Preparation of Calibration Curve:

A linear relationship between absorbance and concentration was observed (Figure 1), confirming the suitability of the calibration curve for determining the drug content in the microspheres. This calibration curve was subsequently used to accurately quantify the amount of **o**meprazole encapsulated within the ethyl cellulose microspheres. Ensuring the precision and accuracy of this calibration process is essential for reliable dosage calculations and further assessments of the drug delivery system's performance.

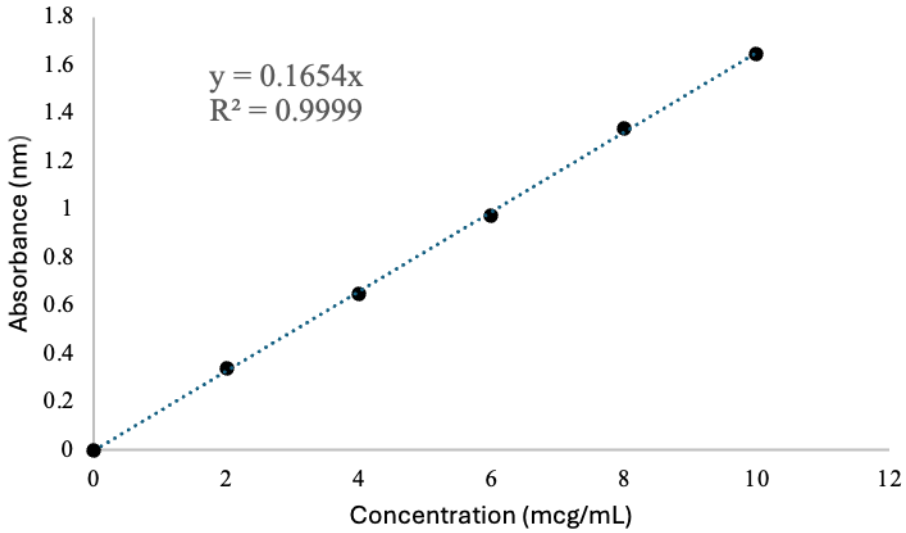


Figure 1: Calibration curve of Omeprazole

Percentage Yield

The calculation provided a quantitative measure of the production efficiency and the reproducibility of the microsphere synthesis process. High percentage yield (93.33%) values indicated successful encapsulation and minimal loss of materials during preparation, signifying the robustness of the solvent evaporation technique utilized. Several factors were found to influence the percentage yield, including the concentration of the polymer used, solvent evaporation rate, and the stirring speed during the formulation process. Optimizing these parameters was crucial in achieving a high yield. It was observed that higher polymer concentrations resulted in increased viscosity of the solution, improving the stability and formation of microspheres, thus enhancing the yield. Additionally, the chosen solvent system played a significant role in the yield efficiency. The selection of an optimum solvent combination and evaporation conditions helped in minimizing the loss of materials during the process. Therefore, the process parameters were fine-tuned to achieve the maximum possible yield without compromising the quality and characteristics of the microspheres. The high percentage yield, combined with efficient drug entrapment and favorable release profiles, confirms the potential of floating hollow microspheres as a promising drug delivery system for poorly water-soluble drugs. Further studies focusing on optimizing these variables could lead to even higher yields and better product consistency.

In comparison to other studies reported in the literature, our formulation method demonstrates a competitive yield. For instance, studies on floating microspheres of famotidine reported a yield of 73.32%[17] suggesting that our formulation process is consistent with or superior to current methodologies.

Drug Entrapment Efficiency

Drug entrapment efficiency (DEE) is a crucial parameter in evaluating the performance of floating hollow microspheres as a drug delivery system. It indicates the proportion of the initial drug that is successfully encapsulated within the microspheres**.** The drug entrapment efficiency of the floating hollow microspheres was found to be 82.41%. This indicates a substantial amount of the initial drug loading was successfully encapsulated within the microspheres, demonstrating the effectiveness of the formulation process. Several factors were identified as influencing the drug entrapment efficiency, including the type and concentration of polymer used, the solvent system, and the drug-to-polymer ratio. The choice of polymer is particularly critical as it affects the interaction between the drug and the polymer matrix, ultimately impacting how well the drug is entrapped within the microspheres. Higher polymer concentrations were found to enhance drug entrapment efficiency, likely due to increased matrix formation which prevents drug leakage.

The solvent evaporation method, a pivotal part of our formulation process, also significantly influenced the entrapment efficiency. A balanced solvent evaporation rate ensured proper solidification of the microspheres, reducing the risk of drug diffusion out of the polymer matrix during formation. Additionally, adjusting the drug-to-polymer ratio was essential in achieving optimal entrapment efficiency; an excess polymer concentration relative to the drug amount helped in better encapsulating the drug within the microspheres. The morphological characteristics observed through Scanning Electron Microscopy (SEM) further supported our findings. The SEM images demonstrated well-formed, spherical microspheres with a hollow core, indicative of efficient encapsulation. Moreover, the X-ray diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR) analyses confirmed the amorphous nature of the entrapped drug, suggesting a uniform distribution within the polymer matrix without crystalline disruption.

Buoyancy Study

The studies demonstrated that a significant percentage (91.3%) of the microspheres maintained buoyancy for a prolonged period (3 hours), indicative of their potential to enhance drug bioavailability by remaining in the stomach for extended periods and ensuring sustained drug release. This high buoyancy is attributed to the hollow core structure of the microspheres, which allows them to remain afloat in the gastric fluid for an extended period. The hollow nature of the microspheres not only aids in prolonged gastric retention but also ensures a consistent release of omeprazole in the simulated gastric fluid. The study's findings are significant as they highlight the efficiency of the solvent evaporation technique in producing microspheres with optimal floating characteristics, thereby enhancing the potential for improved bioavailability of the encapsulated drug. By maintaining their floatation, these microspheres promise an increased residence time in the stomach, which is crucial for drugs like Omeprazole that are specifically targeted for release in the upper gastrointestinal tract. Further, morphological analysis via SEM supported these findings by showing the hollow nature and porous surface characteristics contributing to the microsphere’s floating abilities.

Scanning Electron Microscopy (SEM)

The SEM analysis provided detailed morphological insights into the floating hollow microspheres encapsulating omeprazole. The SEM images displayed that the microspheres were predominantly spherical, maintaining a uniform shape. This spherical morphology is essential for ensuring optimal buoyancy and uniform drug distribution. The surface of the microspheres appeared porous and slightly rough. This porous nature is advantageous for drug release as it increases the surface area available for drug dissolution. The microspheres exhibited a hollow inner core, as evidenced by the cross-sectional SEM images (Figure 2). The hollow structure is beneficial as it reduces the density of the microspheres, enhancing their ability to float on gastric fluids.

The morphological analysis via SEM confirmed that the floating hollow microspheres were successfully formulated with the desired characteristics conducive to a gastro-retentive drug delivery system. The spherical shape and uniform size distribution are critical factors in achieving consistent drug release and buoyancy. The porous surface observed on the microspheres facilitates a controlled and sustained release of omeprazole, which is essential given its poor water solubility. The hollow nature of the microspheres plays a pivotal role in reducing their density, which directly translates to enhanced floating capability in the gastric fluids. This floating ability ensures prolonged gastric residence time, allowing for a more controlled and extended release of omeprazole, potentially leading to improved bioavailability. Moreover, the hollow inner core and porous outer surface suggest that the solvent evaporation method used in the preparation of the microspheres was effective. It ensured adequate encapsulation of Omeprazole while maintaining the structural integrity of the microspheres.

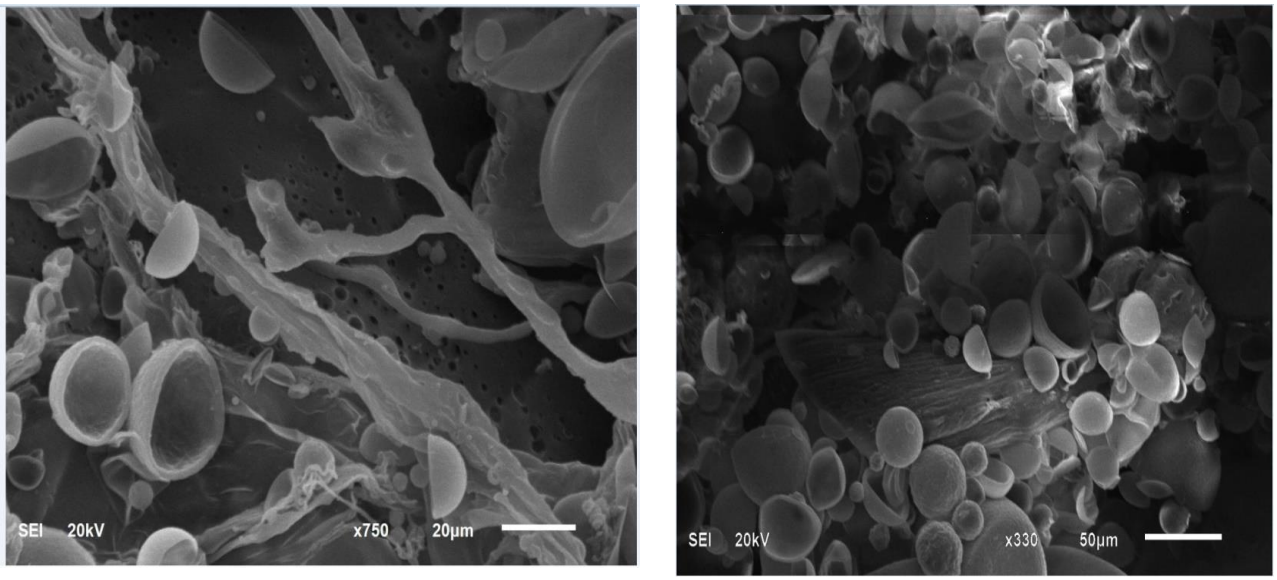
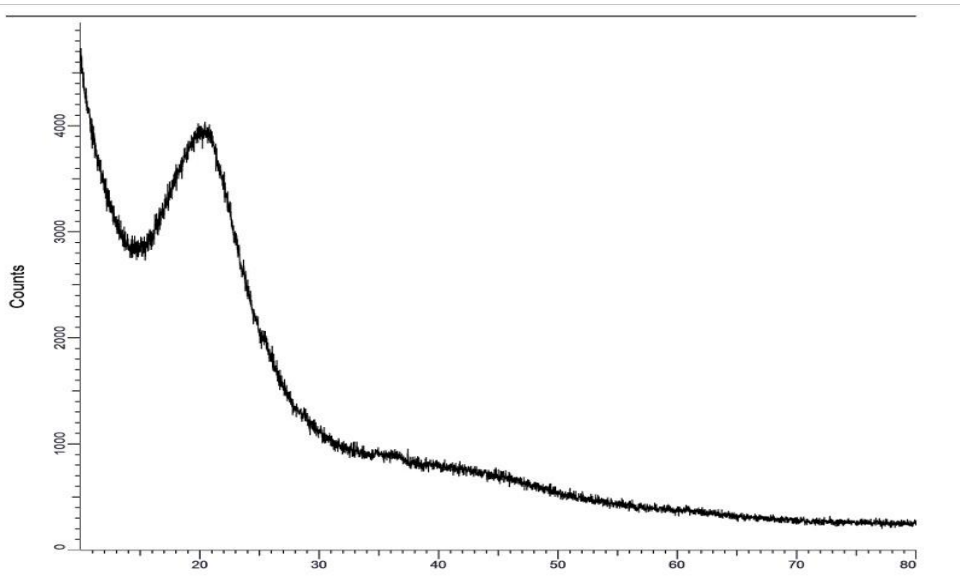


Figure 2: SEM photographs of omeprazole floating microspheres

X-Ray Diffraction Study

The XRD analysis of the floating hollow microspheres revealed significant insights into the crystallinity of the encapsulated omeprazole. The diffraction patterns indicated that the drug within the microspheres exists primarily in an amorphous state (presence of broad peaks), which is advantageous for enhancing its dissolution rate and subsequent bioavailability. These findings are particularly notable because they indicate that the preparation method likely involving solvent evaporation effectively disrupted the crystalline structure of omeprazole (no sharp peaks observed), converting it into an amorphous form without compromising the chemical integrity of the drug, as confirmed by subsequent FTIR analysis. Further, the amorphous form of omeprazole is less prone to the crystallization issues that often plague poorly water-soluble drugs, thereby facilitating a more consistent and efficient release. The transition from a crystalline to an amorphous state suggests that the preparation method employed successfully disrupted the drug's crystalline structure without compromising its integrity. The absence of crystalline peaks in the XRD spectra highlights the effectiveness of the encapsulation process in achieving this desired structural modification. Consequently, these results corroborate the potential of the floating hollow microspheres to serve as an effective gastroretentive drug delivery system, offering a promising solution to the challenges associated with the oral administration of omeprazole.



Experiment

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Figure 3: X-ray diffraction of the prepared hollow microspheres of the omeprazole

Fourier-Transform Infrared (FTIR) Spectroscopy

The FTIR spectra for pure omeprazole, ethyl cellulose, and omeprazole-loaded floating hollow microspheres were recorded and analyzed (Figure 3). Notable absorption bands observed in these spectra were as follows: Pure Omeprazole: characteristic peaks at 3127 cm-1 (O-H stretching), 2981 cm^{-1} and 2932 cm^{-1} (C-H stretching), 1612 cm^{-1} (C=N stretching), and 1450 cm^{-1} (C=C stretching in the benzene ring). Ethyl Cellulose: characteristic peaks at 3480 cm^{-1} (O-H stretching), 2970 cm^{-1} (C-H stretching), 1374 cm^{-1} (C-H bending), and 1105 cm^{-1} (C-O stretching). Omeprazole-Loaded Floating Hollow Microspheres: Notable peaks included those at 3130 cm^{-1} (shifted O-H stretching), 2975 cm^{-1} (C-H stretching), 1610 cm-1 (C=N stretching), 1448 cm^{-1} (C=C stretching in the benzene ring), and 1105 cm^{-1} (C-O stretching).

The FTIR spectra analysis revealed significant insights into the interaction between omeprazole and ethyl cellulose within the floating hollow microspheres. The presence of characteristic peaks for both omeprazole and ethyl cellulose in the FTIR spectrum of the drug-loaded microspheres confirms the successful encapsulation of omeprazole within the ethyl cellulose matrix. The minor shifts in the position of the peaks (e.g., the O-H stretching from 3127 cm^{-1} in pure omeprazole to 3130 cm^{-1} in the microspheres) suggest a possible interaction between the drug and the polymer, likely due to hydrogen bonding or van der Waals forces. These interactions indicate that omeprazole is well-dispersed within the ethyl cellulose matrix.

There were no significant changes in the major functional group peaks of omeprazole and ethyl cellulose, indicating that the encapsulation process did not chemically alter the drug. The integrity of omeprazole's molecular structure was maintained, ensuring its efficacy after encapsulation in the floating hollow microspheres. Further, the compatibility between omeprazole and ethyl cellulose is evidenced by the retention of characteristic peaks and the absence of new peaks, which would indicate the formation of degradation products or significant chemical reactions. This stability is crucial for the sustained release properties of the drug delivery system.

The FTIR spectroscopy results corroborate the effectiveness of the solvent evaporation method in creating stable floating hollow microspheres with encapsulated Omeprazole. The observed interactions between omeprazole and ethyl cellulose support the enhancement of the drug's dissolution rate and bioavailability, as indicated by other characterization studies. Therefore, the use of ethyl cellulose as a polymer matrix in the formation of floating hollow microspheres is a promising approach for improving the oral bioavailability of poorly water-soluble drugs like omeprazole.

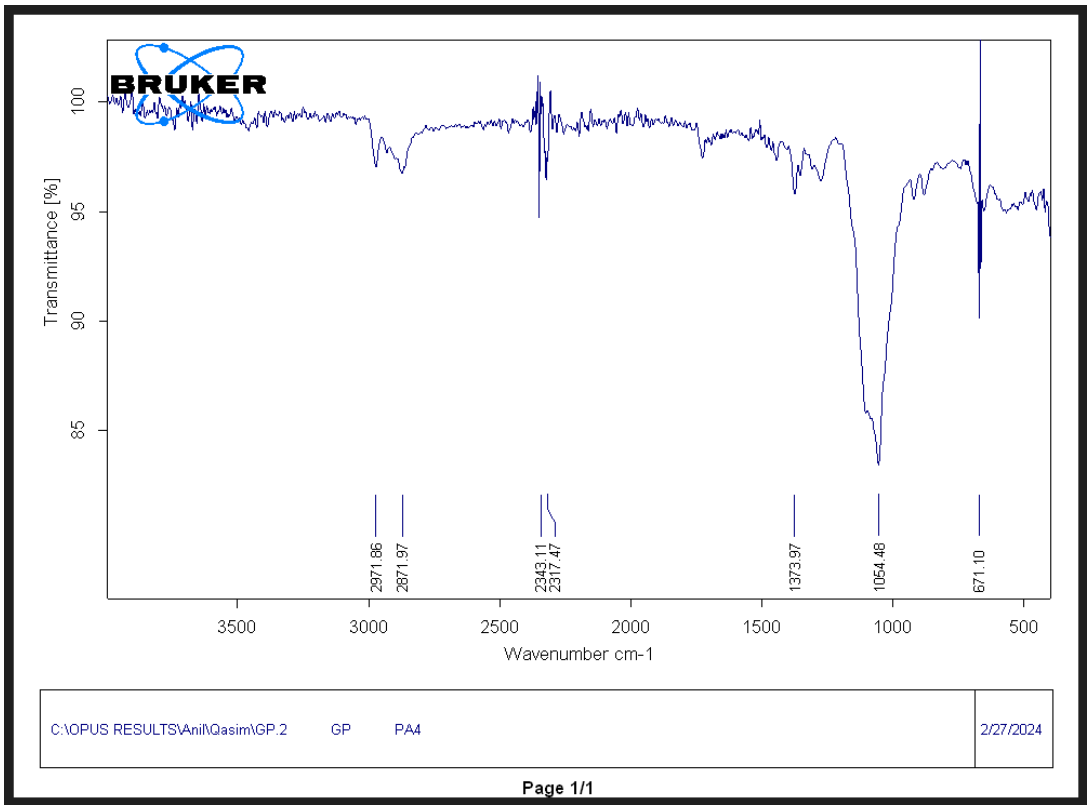

Figure 3: FTIR spectra of the hollow microspheres of omeprazole

In-vitro Drug Release

The in-vitro drug release study of omeprazole-loaded floating hollow microspheres was conducted over a 12-hour period, and the cumulative percentage of drug release was measured at specific time intervals (Figure 4). The release profile demonstrated a biphasic release pattern characterized by an initial burst release followed by a sustained release phase. A rapid release of omeprazole was observed in the first two hours, with approximately 35% of the drug being released. This burst release can be attributed to the presence of drug molecules on or near the surface of the microspheres, which dissolved quickly in the dissolution medium. Following the initial burst, the release rate became more controlled and sustained. Over the next 10 hours, the drug release progressed gradually, culminating in approximately 85% of the total drug being released after 12 hours. This sustained release profile indicates that the majority of the drug was encapsulated within the hollow core of the microspheres and released slowly, governed by the diffusion and erosion of the polymer matrix.

The sustained release pattern observed is typical for polymeric microspheres, where drug diffusion is initially rapid due to higher concentration gradients near the surface, followed by a slower release as the drug diffuses through the polymer matrix. The XRD analysis confirmed the amorphous state of encapsulated omeprazole, which aids in its dissolution and release. The high buoyancy and floating nature of the microspheres were maintained throughout the study period, ensuring prolonged retention in the gastric environment, which is essential for improving the bioavailability of omeprazole. The morphology analysis by SEM indicated that the spherical shape and hollow core of the microspheres provided a larger surface area for interaction with the dissolution medium, facilitating controlled drug release.

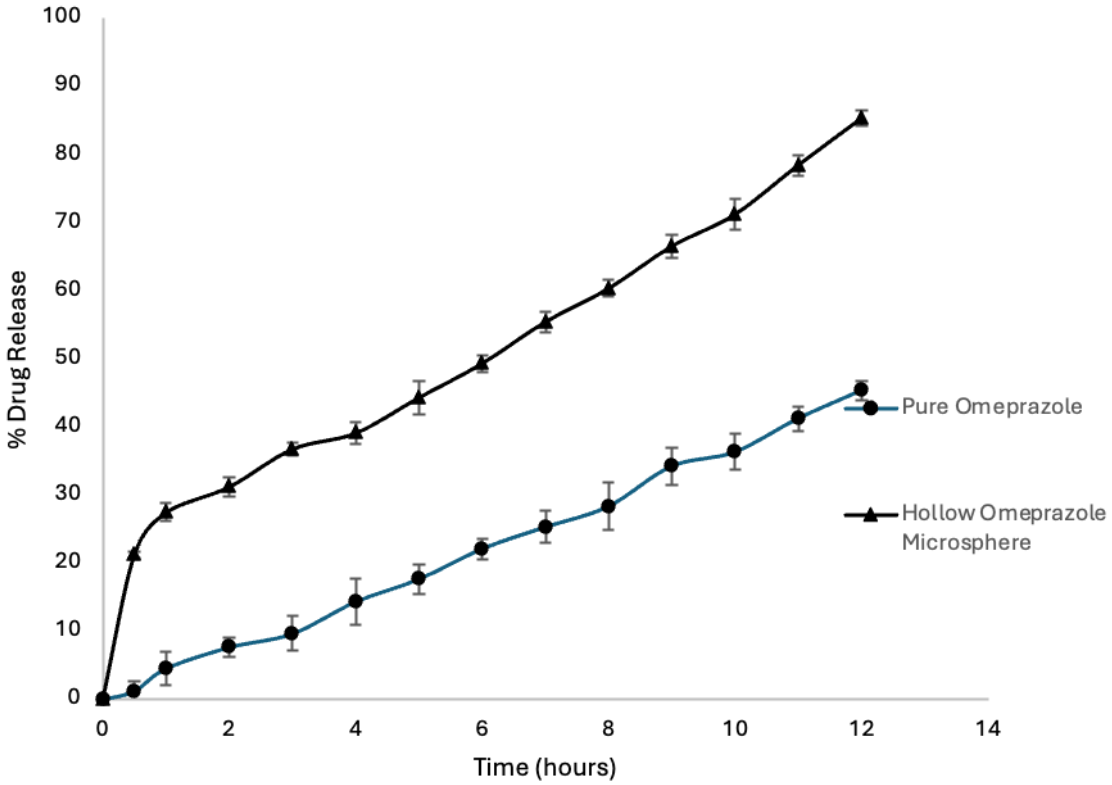

Figure 4: Drug release profiles of pure omeprazole and hollow omeprazole microspheres

IV. Conclusion:

The research highlights the significant potential of floating hollow microspheres in enhancing the oral bioavailability of poorly water-soluble drugs such as Omeprazole. Utilizing the solvent evaporation technique, the study successfully produced microspheres with desirable morphological characteristics, buoyancy, and sustained drug release properties. The findings from in vitro release studies, alongside characterization analyses like FTIR, XRD, and SEM, affirm the stability, proper encapsulation, and effective release mechanisms of the drug within the gastric environment. The promising results warrant further refinement of production processes, stability testing under acidic conditions, and exploration of advanced encapsulation techniques. This innovative

approach holds promise for transforming drug delivery systems, especially for medications with solubility challenges, ultimately improving therapeutic efficacy and patient outcomes.

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Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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