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Research Article

Development and Evaluation of Gastro Retentive Mucoadhesive Microballoons of Esomeprazole to Treat Peptic Ulcer

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Abstract

The Gastro-retentive medication delivery method may increase patient compliance by lowering drug plasma level fluctuations[1]. The absorption maxima (max) of esomeprazole magnesium in 0.1 N HCl solution were found to be at 291 nm. Correlation coefficient values better than 0.99 suggest that the calibration curves provide strong linearity data. The results showed that the medication was soluble in 0.1 N HCl and had the maximum solubility in water. Magnesium esomeprazole was found to have a partition coefficient of (0.2442). The prepared mucoadhesive microballons percentage yield was calculated, with a range of 88.2 to 96.5 percent. The shape and surface morphology of produced mucoadhesive microballons photographed using a scanning electron microscope. The effectiveness of drug entrapment was in the region of 81.71 % - 93.51 % . The swelling rate and percent mucoadhesion of Esomeprazole Magnesium mucoadhesive microballons ranged from 75.63 percent to 88.64 percent. The in-vitro buoyancy % of mucoadhesive microballons used to determine the floating ability of all formulations. All of the developed formulations were floated for at least 7 to 12 hours. The best formulations incorporate naturally occurring polysaccharide polymeric blends as Drug: HPMC: Carbopol 934 (1:1:1) that release more than 98.13 percent of the drug in a regulated and sustained manner in the stomach environment for up to 24 hours.

Keywords: Gastroretention, mucoadhesive microballoons, Esomeprazole, HPMC, Carbopol

INTRODUCTION

Gastro-retentive drug delivery system:[1-4]

It is possible to focus on site-specific medication delivery in the upper GI tract (GIT) for either local or systemic actions by using a strategy called gastro-retentive drug delivery. Such delivery of drugs are primarily affected by two drawbacks: a narrow gastric retention time (GRT) and an unpredictably narrow gastric emptying time (GET). These drawbacks can cause a dosage form's drug release from the absorption zone—the stomach or upper portion of the small intestine—to be incomplete, which can reduce the effectiveness of the dose that was given. It is ideal to extend the drug delivery's stomach residence duration in order to provide a site-specific oral-controlled-release dosage form.

Advantages of GRDDs [5-9]

1. Floating dose structures, for example, tablets or containers, will stay in the liquid for a significant duration even at the basic pH of the colon.
2. FDDS are profitable for drugs with a neighborhood impact in the stomach, like acid neutralizers.
3. FDDS dose structures are valuable in examples of loose bowels and solid gastrointestinal development since they keep the medication in the stomach in a floated condition, taking into consideration a quicker response.
4. The FDDS are compelling for stomach-retained medications like ferrous salts and acid neutralizers.

Mucoadhesive Microballoons: [10-11]

Micro-ballons are small circular particles of micrometer size (normally 1 µm to 1000 µm or 1 millimeter). Micro-balloons, otherwise called microparticles, are round particles of micrometer size. Muco-adhesion delays retention of site abode time.

MATERIAL AND METHODS

MATERIALS: Esomeprazole was provided as a free gift sample by Metrochem API

Pvt. Ltd, Hyderabad, HPMC and Chitosan were procured from Sigma Aldrich and Carbopol

934P was procured from Oryn healthcare LLP.

METHODS: Analytical and Validation studies

A. Determination of absorption maxima (λ_{max}) [12-13]

The absorption maxima of the medication (Esomeprazole Magnesium) were found by filtering the medication arrangement with an UV spectrophotometer somewhere in the range of 200 and 400 nm frequencies. To make a 1000 µg/ml solution, 50 mg of medication was broken up in 50 ml of dissolving medium (0.1 N HCl) in a 50 ml volumetric flask for 20 minutes utilizing a shower sonicator. A definitive arrangement was assigned as Stock-I. 1 ml of this arrangement was diluted up to 100 ml with a similar dissolvable independently and sonicated for 20 minutes to accomplish a 10 µg/ml solution. In a twin pillar UV spectrophotometer, the spectra of these arrangements was estimated somewhere in the range of 200 and 400 nm. (Shimadzu, UV-1800, A11454500755/UV-1800, Shimadzu Corporation, Kyoto, Japan).

The spectrums are shown in **Figure 5.1**.

B. Preparation of calibration curve of Esomeprazole Magnesium in 0.1N HCl [14-15]

Procedure: To make a 1000 µg/ml arrangement, 50 mg of medication was broken up in 50 ml of dissolving medium (0.1 N HCl) in a 50 ml volumetric jar for 20 minutes utilizing a shower sonicator. The last arrangement was named Stock Solution-I. To make a 100 µg/ml arrangement, 10 ml of the recently referenced stock arrangement was blended in with 100 ml of dissolving medium. The last arrangement was named Standard Stock Solution-II. Aliquots of 1 ml, 2.0 ml, 3.0 ml, and 5.0 ml of the previously mentioned standard stock arrangement II were taken and weakened up to 10 ml with matching dissolvable in 10 ml volumetric cups to get convergences of 10 µg/ml, 20 µg/ml, 30 µg/ml, and up to 50 µg/ml, separately. Every arrangement's absorbance was estimated independently at 291 nm for 0.1 N HCl. The absorbance was estimated, and the standard bend for absorbance versus fixation was shown. Figure 5.2 portrays the consequence of linearity.

Preformulation Studies

Organoleptic properties:

The organoleptic characteristics of drug molecule were determined by various sensory organs of body. The result is shown in **Table 5.1**.

Microscopic examination: [16]

The nature and texture of the Esomeprazole Magnesium powder were investigated under the microscope. Under a phase contrast microscope, A little amount of medication powder was placed on a glass slide and viewed. Esomeprazole Magnesium was crystalline in form, as evidenced by the particles.

Physical Characteristics: Density [17]:

The pharmaceutical powder was accurately weighed (M) and gently poured into a graduated cylinder using a glass funnel, with the volume recorded and the bulk density determined. The tapped density was determined using a tapped density instrument. The bulk density of esomeprazole magnesium is 0.312 gm/cm3 and the tapped density is 0.316 gm/cm3.

Particle size:[18]

A microscope (66172/Olympus, 100 X, Olympus (India) Pvt. Ltd., New Delhi) equipped with an ocular micrometre and a stage micrometre was used to estimate the average particle size (davg) of the medication. Unmilled Esomeprazole Magnesium powder has a particle size of 78 m.

Flow properties:[19]

Carr's index, hausner's ratio, and angle of repose were used to describe the flow characteristics of Esomeprazole Magnesium powder. The Carr's index ((IC)) and Hausner's ratio (HR) of drug powders were calculated using the equations below:

Carr's Index (IC) = ρTapped - ρBulk / ρTapped Hausner's ratio (HR) = ρTapped / ρBulk

The angle of repose was determined using the fixed height approach. The following equation was used to compute this:

Angle of repose (θ) = $\tan^{-1}$ 2 H / D

Where H is the surface area of the powder heap's free standing height and D is the diameter of the heap generated following powder flow from the glass funnel.

The unmilled powder of Esomeprazole Magnesium had good flow properties, but following milling, the material had exceptional flow properties. Table 5.2 shows the results of flow characteristics.

Solubility determination:[20]

The dissolvability of the prescription Esomeprazole Magnesium was attempted in water, N HCl, phosphate support pH 4.5, phosphate support 6.8, and phosphate pad 7.4. To avoid oxidation, sodium thiosulphate was added to the medium when phosphate support pH 6.8 and phosphate support pH 7.4 were used. Excess Esomeprazole Magnesium was added to 100 ml of medium and spun persistently until further notice at 370.5oC. Using the UV-Visible spectrophotometric technique referred to over, the dissolvability of the medicine Esomeprazole Magnesium in various mediums was broke down. The findings are shown in Table 5.3.

Partition coefficient:[21]

The partition coefficient of the medication (Esomeprazole Magnesium) was acquired in a n-octanol: N HCl arrangement. A painstakingly gauged (100 mg) portion of medication was acquainted with 25 ml of every n-octanol and support gradually ease in an isolating pipe. The combination was shaken for 24 hours to accomplish harmony. Independently, the two stages were isolated, gathered, and sifted. An UV-Visible spectrophotometric approach was utilized to measure how much medication broke down in water. The amount of medication in the natural stage was assessed by deducting how much medication in the fluid stage from the aggregate sum of medication taken. The segment coefficient of a medication was determined utilizing the accompanying condition involving the proportion of medication focuses in the natural and fluid phases.Log P (n-oct/0.1 N HCl) = Log (C n-Oct/C 0.1 N HCl) balance.

The partition coefficient of Esomeprazole Magnesium was found to be (0.2442).

Drug- Excipient compatibility study:

Drug-excipient combinations for compatibility testing (Table 4.1).

Batch no.	Drug-excipient combinations
S1	Pure drug Esomeprazole Magnesium
S2	Esomeprazole Magnesium + all excipients

The amount of Esomeprazole Magnesium in each sample was determined using a UV-visible spectrophotometric technique, with the results reported in Table 5.6. Figures 5.3 to 5.4 show the FTIR spectrums. Result and discussion detailed the typical peaks of Esomeprazole Magnesium, l Esomeprazole Magnesium with all excipients.

Preparation of mucoadhesive Microballons:[22]

A non-aqueous solvent evaporation approach was used to make buoyant mucoadhesive microballons with Esomeprazole Magnesium as the core ingredient. HPMC, Chitosan, and Carbopol 934 were the different polymers used in the development of buoyant mucoadhesive Microballons. Table 4.2 shows the components of several formulations. Medication and polymer were blended in a 1:1 dissolvable mix in different amounts of 1:1, 1:2, and 1:1:1. This clear mixture was poured tenderly as a dainty stream in a fluid stage, comprising of 150 ml of 0.1 M acidic arrangement containing polyvinyl liquor. The arrangement was precisely upset at 500 rpm at room temperature for 2 hours to permit the dissolvable to totally vanish and the mucoadhesive Microballons to be recuperated by decantation. The mucoadhesive Microballons were cleaned three times in water separately. The mucoadhesive Microballons were collected and dried at room temperature for 1 hour before being kept in a dessicator over fused calcium chloride.

Table 4.2: Esomeprazole Magnesium (A1 - B3) Mucoadhesive Microballons Preparation[23]

S. No.	Code	Ingredients	Drug : Poly mer	Qty (mg)	Organic Solvent System	Stabilizing agent (PVA) (% w/v)
1	A1	Drug : HPMC	1:1	150:150	Dichloromethane: ethanol	1
2	A2	Drug : HPMC	1:2	100:200	Dichloromethane: ethanol	1
3	CH1	Drug : Chitosan	1:1	150:150	Dichloromethane: ethanol	1
4	CH2	Drug : Chitosan	1:2	100:200	Dichloromethane: ethanol	1
5	CA1	Drug : Carbopol 934	1:1	150:150	Dichloromethane: ethanol	1
6	CA2	Drug : Carbopol 934	1:2	150:300	Dichloromethane: ethanol	1
7	B1	Drug : HPMC:Chitosan	1:1:1	100:100:100	Dichloromethane: ethanol	1
8	B2	Drug : HPMC:Carbopol 934	1:1:1	100:100:100	Dichloromethane: ethanol	1
9	B3	Drug : Chitosan:Carbopol 934	1:1:1	100:100:100	Dichloromethane: ethanol	1

Evaluation of mucoadhesive microballons: [24-26]

Percentage yield determination: Following drying, the produced mucoadhesive microballons were weighed to determine the actual yielding after the preparation process. The outcome is presented in Table 5.7. The % yield of produced mucoadhesive Microballons was estimated using the formula shown below:

Percentage Yield = (Actual weight x 100)/ Theoretical Weight

Shape and surface morphology: Scanning electron microscopy (SEM, JealJX 840- A, Tokyo, Japan) was utilised to examine the surface of the generated mucoadhesive Microballons. To prepare samples for SEM, the powder was sparsely dusted over a double adhesive tape glued to an aluminium stub. Under low pressure, the gold film was then placed on the stubs. This film acts as a conducting medium, allowing an electron stream to pass through before being imaged using a scanning electron microscope. (Figure 5.5 – 5.6).

Particle size analysis: Mucoadhesive microballons were examined under the microscope for size and size distribution using a calibrated ocular micrometre. The outcome was depicted in **Table 5.8**.

4.4.3. Drug Entrapment Efficiency: To assess the drug entrapment effectiveness of mucoadhesive microballons, 500mg of drug-containing microballons were triturated and suspended in a tiny quantity of dichloromethane (10ml) to dissolve the Microballons' coat shell. The suspension was diluted with 0.1N HCl buffer (100mL) for 1 hour and filtered to separate the shell pieces. Following an acceptable dilution, the drug entrapment efficiency was evaluated spectrophotometrically at 228 nm using a UV-detector (Shimadzu, UV-1800). The outcome is shown in Table 5.9. The following formula was used to compute the drug

entrapment efficiency:

$$\text{Drug entrapment efficiency} = \frac{\text{Calculated drug concentration} \times 100}{\text{Theoretical drug content}}$$

Degree of Swelling of microballons [27]: 1 gramme of microsphere was suspended in 5 mL of simulated gastric fluid USP to determine the degree of swelling (pH 1.2). Every 1 hour, the particle size was measured using a microscopy technique using an optical microscopic examination (Labomed CX RIII). For up to 8 hours, the particle size of the Microballons increased. Table 5.10 displays the outcome.

The formula used for calculation of degree of swelling is given below

Swelling (%) = (Ws - Wd)/Wd × 100

Microballons wash-off test in vitro[28]: For this analysis, a 1 cm piece of rodent stomach mucosa was strung onto a glass slide. A sodden, washed tissue example was scattered with around 100 Microballons, and the pre-arranged slide was suspended in the notches of a USP pill dissolving test mechanical assembly. The deterioration test gadget was designed so that the tissue example in a measuring glass containing reproduced stomach liquid USP was pushed all over consistently (pH 1.2). The amount of Microballons remaining sticking to the tissue was surveyed at 1 hr, 5 hr, and 10 hr stretches. Table 5.11 presentations the result.

In-vitro floating rate: Mucoadhesive microballons were applied to the outer layer of a USP XXIV dissolving gadget (type II) stacked with 900 ml of 0.1 N hydrochloric corrosive containing 0.02 percent Tween 80. (0.3 g). An oar pivoting at 100 rpm was utilized to unsettle the vehicle for 24 hours. The floating and setteled areas of mucoadhesive Microballons were recuperated independently. Mucoadhesive microballons were dried and gauged. The floating rate was determined by partitioning the mass of the drifting Microballons by the complete mass of Microballons. Table 5.12 showcases the result.

In vitro drug discharge review in recreated gastrointestinal liquids[29]: The disintegration of Esomeprazole Magnesium mucoadhesive microballons was tried utilizing the oar type-II dissolving device characterized in USP XXIII. 500 mg of Esomeprazole-stacked microballons were precisely gauged and similarly dispersed across the outer layer of 900 mL of dissolving media. At 37 0.5°C, the data was turned at a speed of 100 revolutions each moment. During the medication crumbling, the sink condition was great. The delivery was assessed in SGF disintegration medium (pH 1.2). At predefined time spans, an aliquot of the delivery medium was taken and a comparable amount of new medium was acquainted with the delivery media. The acquired examples were separated utilizing a 0.45m needle channel (Millipore millex HN) and spectrophotometrically assessed. The observations are recorded in **Table 5.13 – 5.21** and graphically shown in **Figure 5.7 – 5.8**.

RESULT AND DISCUSSION

Analytical and Preformulation studies of model drug [29.30]

In 0.1 N HCl solution, the absorption maxima (λmax) of Esomeprazole Magnesium (10 g / ml) were reported to be at 291 nm. Figure 5.1 depicts a spectrum peak point graph of medication absorbance vs. wavelength. UV spectrophotometric methods were used to evaluate the medication Esomeprazole Magnesium in vitro. According to the available laboratory conditions, the stated UV spectrophotometric procedures were slightly adjusted and optimised. In the dissolving medium, the medicines were estimated (0.1 N HCl). Drug solutions of known concentrations were used to create calibration curves in various dissolving mediums (0.1 N HCl). The absorbance was measured and the drug concentration was shown (Figure 5.2).

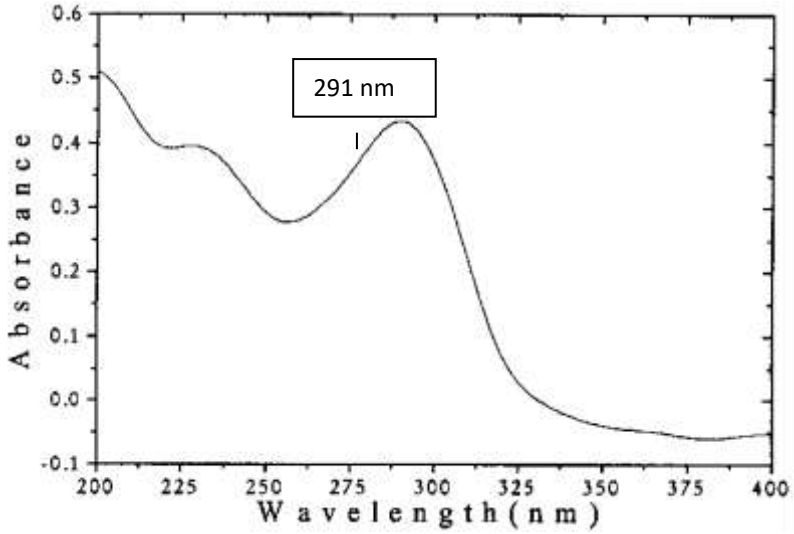

Figure 1: The absorbance was measured and the drug concentration was shown **30**.

The calibration curves provide good data linearity, as shown by correlation coefficient values greater than 0.99. The drug's concentration curves were found to be recti-linear in the concentration range of 0 g/ml to 80 g/ml.

Table 5.1 Pure drug absorbance with their respective concentrations[31]

Concentration(µg/ml)	Absorbance(nm)
5	0.146
10	0.304
15	0.462
20	0.608
25	0.753

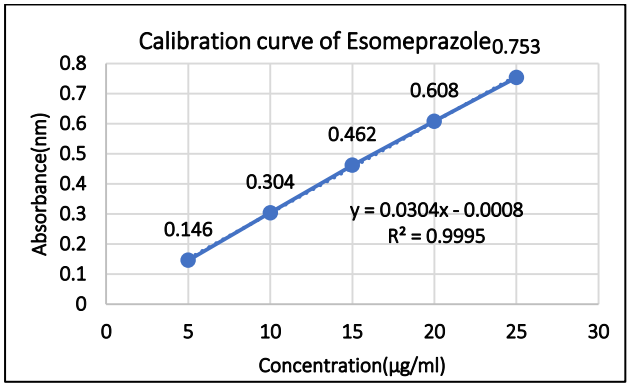

Figure 5.2: Standard curve of Esomeprazole Magnesium in 0.1N HCl

Preformulation Studies [31,32]

Preformulation studies are the initial phase in the objective making of dose structures for model restorative particles. It is the investigation of the physical and synthetic qualities of drug substances, both alone and in blend with excipients, in research. The general motivation behind preformulation research is to give pertinent data to the formulator in the production of steady and bioavailable dose structures. Esomeprazole Magnesium is a translucent powder with a whitish yellow tone, a marginally impactful smell, and a somewhat charming taste (Table 5.1). 0.312 gm/cm3 and 0.316 gm/cm3 are the mass and tapped densities, individually. The unmilled powder's normal molecule size (davg) was 78 m. The stream properties of the medication powder were magnificent (Table 5.2). The prescription's dissolvability in different not entirely settled at room temperature (252 oC) (Water, 0.1 N HCl, Phosphate cushion pH 4.5, pH 6.8, pH 7.4). The discoveries are displayed in Table 5.3. The medication disintegrated best in water and was likewise dissolvable in 0.1 N HCl, as per the information. The segment coefficient of esomeprazole not entirely settled to be (0.2442). The examples were investigated for FTIR location as well as actual examination to decide the communication between the medication and the excipients. The adjustment of the actual qualities of drugs was explored, as well as the medication content of blends and IR tests (Tables 5.4-5.6). Figures 5.3 to 5.4 show the FTIR range. The characteristic peaks of Esomeprazole Magnesium were observed at 3280, 3210, 3107, 3094, 2945, 2860, 2829, 2784, 1622, 1587, 1470, 1458, 1435, 1422, 1377 and 1359 cm^{-1}

Table 5.1: Organoleptic characteristics of Esomeprazole Magnesium[33]

Properties	Esomeprazole Magnesium
Color	Whitish yellow
Odor	Slightly pungent
Taste	Slightly sweet

Table 5.2: Drug flow characteristics (n = 3)[34]

Drug	Type of powder	Carr's index (%)a	Hausner's ratio a	Angle of repose θ a
Esomeprazole Magnesium	Unmilled	12.28±0.011	1.13±0.011	26.6±0.101
	Milled	9.86±0.012	1.11±0.013	19.3±0.043

a; all values are in mean ± Standard deviation

Table 5.3: The solubility of Esomeprazole Magnesium at different pH medium (n=3) [35]

Media	Solubility (mg / ml)	Mean
Water	18.93	18.97
0.1 N HCl	22.33	22. 65
Phosphate buffer pH 4.5	14.91	14. 96
Phosphate buffer pH 6.8	13.01	13. 02
Phosphate buffer pH 7.4	17.94	17.93

Drug-excipient combinations for compatibility testing are shown in Table 5.4. [36]

Batch no.	Drug-excipient combinations
S1	Pure drug Esomeprazole Magnesium
S2	Esomeprazole Magnesium + all excipients

Table 5.5: Results of physical observation[37]

Batch No.	Initial observation	40±2 ºC				25±2 ºC or Room temperature			
		I week	II week	III week	IV Week	I week	II week	III week	IV week
S1	White yellow Crystals	++	++	++	++	++	++	++	++
S2	Pale Yellow Crystals	++	++	++	++	++	++	++	++

++ Indicated no color change and no lump formation

Table 5.6: Results of content determination[38]

Batch No.	Initial observation (%)	40±2 ºC		25±2 ºC or Room temperature	
		I week (%)	II week (%)	I week (%)	II week (%)
S1	99.99	98.81	96.87	99.34	97.17
S2	99.94	98.69	97.02	99.02	97.03

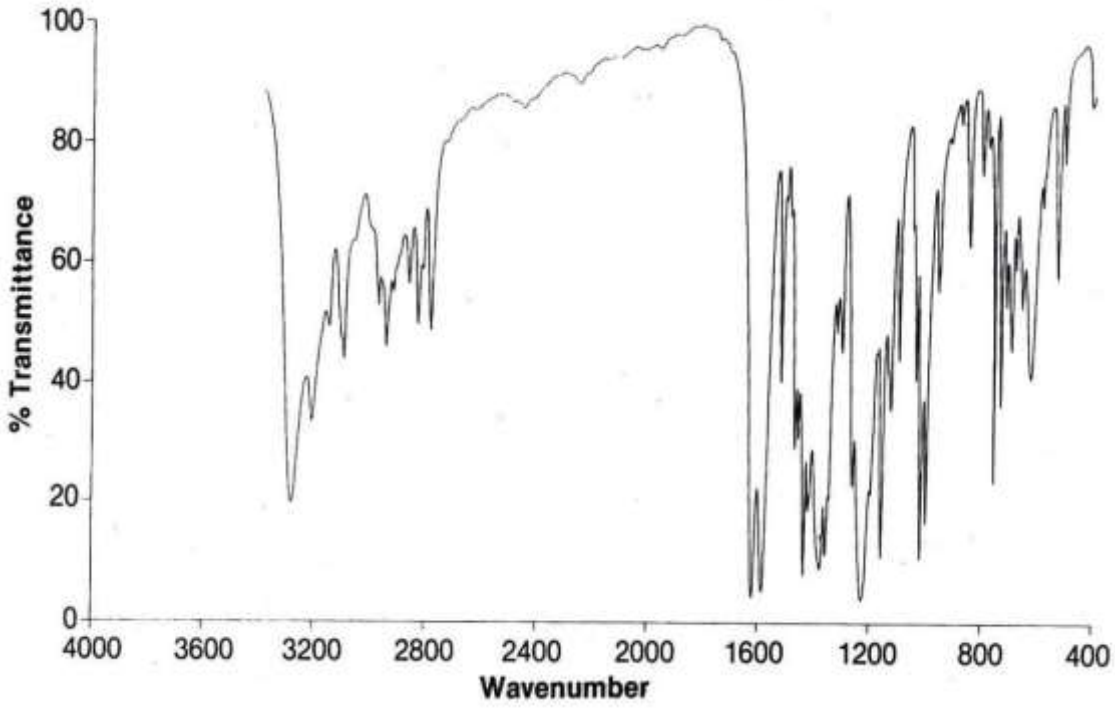

Figure 5.3: The I. R. spectrum of a pure Esomeprazole Magnesium sample (S1)[39]

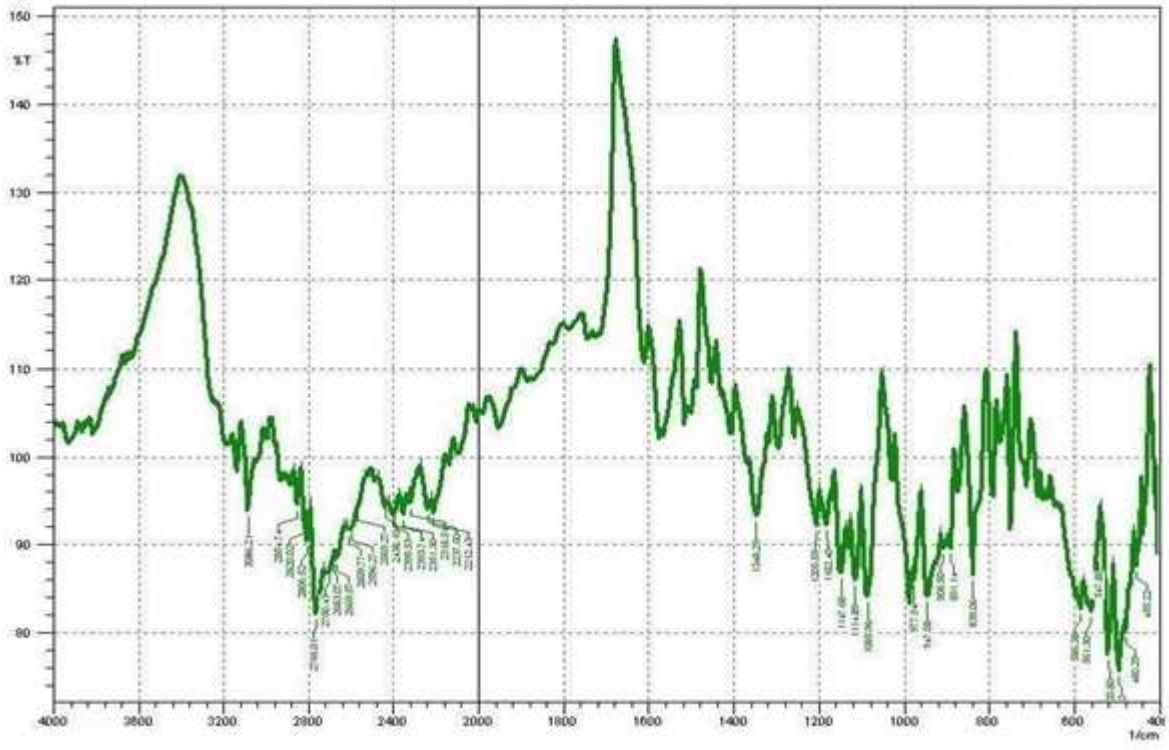

Figure 5.4: I. R. spectrum of Esomeprazole Magnesium sample and all excipients (S2)[40]

Evaluation of mucoadhesive microballons:

The percentage yield of the prepared mucoadhesive Microballons was determined, with a range of 88.2 percent to 96.5 percent. Figure 5.5 – 5.6 depicts the shape and surface morphology of produced mucoadhesive microballons photographed using a scanning electron microscope. Microscopically, the particle size of prepared mucoadhesive microballons was investigated, and the results are shown in Tables 5.13–5.14. All of the formulations demonstrated good flowability, with particle sizes ranging from 361.45 m to 383.24 m on average.

The Drug Entrapment Efficiency of produced mucoadhesive Microballons was investigated for drug entrapment efficiency determination, and the results are displayed in Table 5.15. The drug entrapment efficiency was found to be between 81.71 and 93.51 percent. Table 5.16 shows the degree of swelling of microballons. The swelling rate and percent mucoadhesion of Esomeprazole Magnesium mucoadhesive Microballons ranged from 75.63 percent to 88.64 percent. Table 5.17 shows the in-vitro buoyancy % of mucoadhesive Microballons for determining the floating ability of all formulations. For at least 7 to 12 hours, all of the created formulations floated. The findings of in vitro drug release experiments in simulated gastrointestinal fluids of SGF (pH 1.2) and the observations are listed in Tables 5.18–5.26.

The percentage of release and release rate k of tablets were determined in vitro. The following release data were chosen and fitted to a mathematical model of zero order:

$Q = C + kt$

Where Q is the release percentage at time t, k is the slope of the fitted linear equation, R is the release rate, and C is the linear equation's intercept. Tlag is the time when plumbagin release begins, and it is computed using the fitted equation with

$Q=0: Tlag = - C / k.$

Only correlation coefficients of over 0.99 are acceptable in the linear equation, which is based on regression of at least three release data. Figure 5.8 – 4.9 shows the outcomes of Esomeprazole Magnesium including floating mucoadhesive Microballons. The best formulations incorporate naturally occurring polysaccharide polymeric blends as Medication: HPMC: Carbopol 934 (1:1:1) that release more than 98.13 percent of the drug in a regulated and sustained manner in the stomach environment for up to 24 hours. The slope values were calculated from the graph using regression analysis, and the r2 values indicated that the curves were fairly linear. The value of the release exponent "n" was more than 0.89 for all batches, indicating a Super-case II transport mechanism.

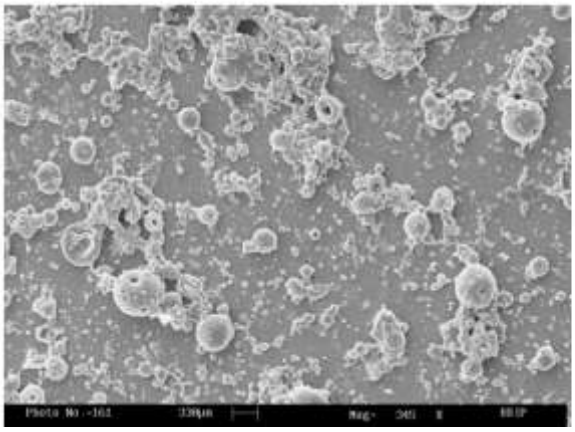
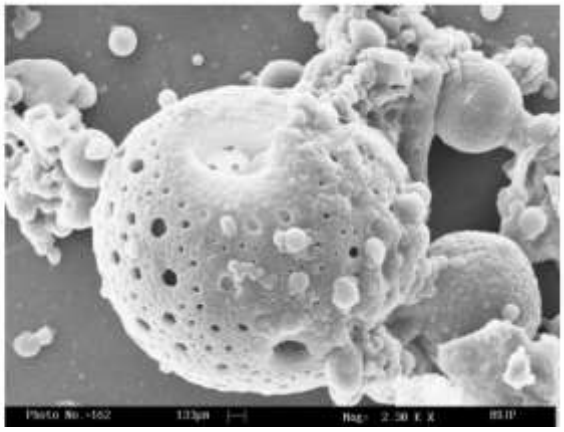

Figure 5.5 & 5.6: SEM photomicrograph of microballoons [41]

Table 5.7: Esomeprazole Magnesium (A1 - B3) mucoadhesive microballons yield (%)[42]

S. No.	Code	Ingredients	Drug: Polymer	Theoratical yield (gm)	practical yield (gm)	percentage yield (%)
1	A1	Drug : HPMC	1:1	3	2.646	88.2
2	A2	Drug : HPMC	1:2	3	2.748	91.6
3	CH1	Drug : Chitosan	1:1	3	2.769	92.3
4	CH2	Drug : Chitosan	1:2	3	2.649	88.3
5	CA1	Drug : Carbopol 934	1:1	3	2.672	89.1
6	CA2	Drug : Carbopol 934	1:2	3	2.736	91.2
7	B1	Drug : HPMC:Chitosan	1:1:1	3	2.796	93.2
8	B2	rug : HPMC:Carbopol 934	1:1:1	3	2.895	96.5
9	B3	Drug : Chitosan:Carbopol 934	1:1:1	3	2.745	91.5

Table 5.8: Mucoadhesive microballons of Esomeprazole Magnesium particle size (A1 - B3)[43]

S. No.	Code	dmean (µm)
1	A1	361.45±0.540
2	A2	372.86±0.436
3	CH1	371.15±0.495
4	CH2	377.10±0.512
5	CA1	382.12±0.436
7	B1	381.17±0.435
8	B2	383.24±0435
9	B3	381.86±0.532

Table 5.9: Esomeprazole Magnesium (A1 - B3) drug entrapment efficiency in mucoadhesive microballons[44]

S. No.	Code	Drug content (mg./gm. of microspheres)	Encapsulation efficiency (%)
1	A1	428.1	85.62
2	A2	272.1	81.71
3	CH1	431.2	86.24
4	CH2	281.1	84.41
5	CA1	427.8	85.56
6	CA2	278.8	83.72
7	B1	301.2	90.45
8	B2	311.4	93.51
9	B3	303.8	91.23

Table 5.10: Swelling degree of Esomeprazole Magnesium mucoadhesive microballons (A1 - B3)[45]

S. No.	Code	Swelling rate (%)
1	A1	42.5 ± 1.15
2	A2	44.6 ± 1.18
4	CH2	49.2 ± 1.38
5	CA1	53.9 ± 2.48
6	CA2	55.9 ± 2.48
7	B1	58.9 ± 2.48
8	B2	61.5 ± 0.76
9	B3	59.9 ± 2.48

Table 5.11: Mucoadhesion percentage of mucoadhesive microballons of Esomeprazole Magnesium (A1-B3)[46]

S. No.	Code	Percent Mucoadhesion
1	A1	75.63 ± 0.018
2	A2	77.64 ± 0.077
3	CH1	81.22 ± 0.123
4	CH2	84.64 ± 0.198
5	CA1	85.57 ± 0.208
6	CA2	81.64 ± 0.110
7	B1	83.64 ± 0.111
8	B2	88.64 ± 0.198
9	B3	86.64 ± 0.198

Table 5.12: Buoyancy test of mucoadhesive microballons of Esomeprazole Magnesium (A1 - B3)[47]

S. No.	Code	Buoyancy (%)			DOF (h)
		4 h	8 h	12 h	
1	A1	55.1	23.8	21.1	> 7
2	A2	55.2	27.1	23.3	> 7
3	CH1	62.4	31.9	20.4	>7
4	CH2	67.1	32.1	21.1	> 8
5	CA1	66.1	33.3	23.1	> 8
6	CA2	71.4	41.1	21.7	> 12
7	B1	76.2	43.1	23.1	> 12
8	B2	88.2	50.1	30.1	> 12
9	B3	75.2	44.3	25.1	> 12

Table 5.13: Dissolution statistics of mucoadhesive microballons of Esomeprazole Magnesium (A1 - B3)[48]

Time	A1	A2	CH1	CH2	CA1	CA2	B1	B2	B3
0	0	0	0	0	0	0	0	0	0
2	4.71	3.01	1.54	0.781	4.68	3.23	0.571	0.322	1.23
4	13.21	8.23	5.43	3.45	10.12	9.23	1.76	2.45	3.39
6	18.68	10.34	9.23	7.46	18.34	15.67	5.67	4.67	3.39
8	35.67	19.87	19.87	13.23	27.45	26.78	12.34	16.46	14.5
10	45.27	31.23	31.25	26.56	38.54	33.24	25.67	26.56	21.34
12	53.25	41.34	44.78	38.34	47.65	44.28	36.45	38.78	37.56
14	66.34	53.37	52.34	48.34	59.67	53.68	46.78	49.87	58.45
16	76.54	65.78	64.21	58.34	75.6	69.76	59.04	59.03	74.23
18	88.74	77.45	74.34	69.87	84.34	79.32	69.34	71.23	86.46
20	95.37	87.32	82.1	81.26	91.23	89.65	79.67	81.23	93.6
22	98.12	97.51	92.1	91.36	96.99	94.78	90.23	91.13	98.01
24	99.99	99.24	99.68	99.21	99.98	99.78	99.01	98.13	99.34

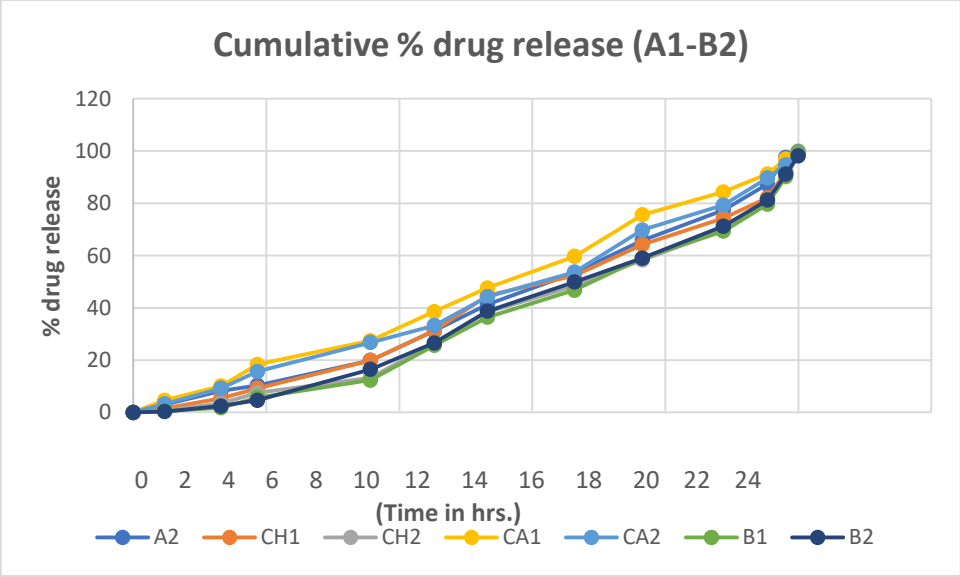

Figure 5.7: Cumulative % drug release from all formulations (A1-B2)[49]

SUMMARY AND CONCLUSION

In 0.1 N HCl solution, the absorption maxima (λmax) of Esomeprazole Magnesium (10 µg / ml) were reported to be at 291 nm. The calibration curves demonstrate excellent linearity of data, as shown by correlation coefficient values better than 0.99. Esomeprazole Magnesium is a crystalline powder with a whitish yellow colour, a slightly pungent odour, and a mildly pleasant taste (Table 5.1). 0.312 gm / cm3 and 0.316 gm / cm3 are the bulk and tapped densities, respectively. The unmilled powder's average particle size (davg) was 78 m. The flow properties of the drug powder were excellent (Table 5.2). The medication had the highest solubility in water and was also soluble in 0.1 N HCl, according to the findings. Esomeprazole Magnesium was discovered to have a partition coefficient of (0.2442). Figure 5.3 to 5.4 depicts the FTIR spectrum. Esomeprazole Magnesium had distinctive peaks at 3280, 3210, 3107, 3094, 2945, 2860, 2829, 2784, 1622, 1587, 1470, 1458, 1435, 1422, 1377, and 1359 cm-1.

The percentage yield of the prepared mucoadhesive microballons was determined, with a range of 88.2 percent to 96.5 percent (Table 5.7). Figure 5.5 – 5.6 depicts the shape and surface morphology of produced mucoadhesive microballons photographed using a scanning electron microscope. Microscopically, the particle size of prepared mucoadhesive microballons was investigated, and the results are displayed in Table 5.8. All of the formulations demonstrated good flowability, with particle sizes ranging from 361.45 mm to 383.24 mm on average.The drug entrapment efficiency was in the range of 81.71 % - 93.51 % (Table 5.9). Table 5.10 shows the degree of swelling of microballons. The swelling rate and percent mucoadhesion of Esomeprazole Magnesium mucoadhesive microballons ranged from 75.63 percent to 88.64 percent. Table 5.11 shows the in-vitro buoyancy % of mucoadhesive microballons used to determine the floating ability of all formulations. All of the developed formulations were floated for at least 7 to 12 hours (Table 5.12).

The best formulations incorporate naturally occurring polysaccharide polymeric blends as Medication: HPMC: Carbopol 934 (1:1:1) that release more than 98.13 percent of the drug in a regulated and sustained manner in the stomach environment for up to 24 hours. The slope values were calculated from the graph using regression analysis, and the r2 values indicated that the curves were fairly linear. The value of the release exponent "n" was more than 0.89 for all batches.

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