



Formulation Development and Evaluation of Mini Tablet of Ciprofloxacin

C. Susmitha*¹, Zeenath Ruhy², P. Aravinda Reddy³

¹Department of Pharmaceutics, Mother Teresa College of Pharmacy, NFC Nagar Ghatkesar, Telangana India- 501301.

²Assistant Professor, Mother Teresa College of pharmacy, NFC Nagar Ghatkesar, Telangana India- 501301.

³Principal and Professor, Mother Teresa College of Pharmacy, NFC Nagar Ghatkesar, Telangana India- 501301.

ABSTRACT

The present research focused on the development of sustained release matrix tablets of Ciprofloxacin targeted to the colon using various polymers. To achieve pH-independent drug release, buffering agents were incorporated as pH modifiers. Colon-targeted tablets were formulated in two steps: preparation of core tablets followed by coating with pH-dependent polymers. Ethyl cellulose, Eudragit L100, and Eudragit S100 were employed as enteric coating agents. The pre-compression blends of all formulations exhibited satisfactory flow properties, and the coated tablets complied with pharmacopoeial quality evaluations. Among the different batches, formulation F3 was identified as the optimized formulation, as it effectively sustained drug release up to 12 hours and achieved 98.69% cumulative release. The drug release kinetics of the optimized formulation followed the zero-order mechanism, confirming its suitability for sustained release. Thus, the developed formulation shows promise as a colon-targeted drug delivery system for Ciprofloxacin, with the potential to improve therapeutic efficacy and patient compliance.

Keywords: Ethyl cellulose, Eudragit L100, Ciprofloxacin, Eudragit S100, zero-order mechanism

ARTICLE INFO

Corresponding Author

C. Susmitha

Department of Pharmaceutics

Mother Teresa College of Pharmacy

NFC Nagar Ghatkesar, Telangana India- 501301.

Article History

Received : 28 July 2025

Revised : 10 Aug 2025

Accepted : 11 Sept 2025

Published : 21 Oct 2025

Copyright© 2025 The Contribution will be made Open Access under the terms of the Creative Commons Attribution-NonCommercial License (CC BY-NC) (<http://creativecommons.org/licenses/by-nc/4.0>) which permits use, distribution and reproduction in any medium, provided that the Contribution is properly cited and is not used for commercial purposes.

Citation: C. Susmitha, et al. Formulation Development and Evaluation of Mini Tablet of Ciprofloxacin. A. J. Med. Pharm, Sci., 2025; 13(2): 119-125.

CONTENTS

1. Introduction.	119
2. Function.	120
3. Epidemiology.	122
4. Conclusion.	124
5. References.	124

1. Introduction

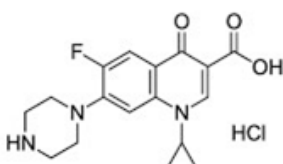


Fig.1: Ciprofloxacin

Molecular Formula: C₁₇H₁₈FN₃O₃

Molecular Weight: 331.34 g/mol

IUPAC Name: 1-cyclopropyl-6-fluoro-4-oxo-7-(piperazin-1-yl)-quinoline-3-carboxylic acid

ChemSpider ID: 2662

Density: ~1.46 g/cm³ (predicted)

Boiling Point: ~582 °C (predicted)

Melting Point: 255–257 °C

Vapour Pressure: Not readily volatile

Flash Point: Not applicable (solid)

Refractive Index: Not typically reported for solids

Polar Surface Area: ~74 Å²

LogP (Octanol/Water): ~0.28

Generic Name : Ciprofloxacin

Brand Names: Cipro, Ciprobay, Ciloxan, Baycip

Drug Category: Fluoroquinolone antibiotic

Indications : UTIs, respiratory infections, skin infections, anthrax, typhoid, etc.

Pharmacology: Inhibits bacterial DNA gyrase and topoisomerase IV

Potency : Broad-spectrum; effective at low concentrations

Tolerability: Generally well-tolerated; GI upset common
Contraindications: Hypersensitivity to quinolones; caution in myasthenia gravis Adverse Effects: Nausea, diarrhea, tendon rupture, CNS effects (rare)

Availability:
 Widely available globally; oral, IV, ophthalmic, and otic forms

2. Materials and Methods

Table.1: List of Materials Used

S.no	Name of the material	Purpose	Source	Quality
1	Ciprofloxacin	Drug	Natco LABS	Lab.Grade
2	Ethyl Cellulose	Polymer	Signet Chemical Corporation, Mumbai, India.	Lab.Grade
3	Eudragit L-100	Polymer	Merck Specialities Pvt Ltd, Mumbai, India.	Lab.Grade
4	Eudragit S-100	Polymer	Merck Specialities Pvt Ltd, Mumbai, India.	Lab.Grade
5	Hydroxy Propyl Methyl Cellulose K100M	Polymer	Merck Specialities Pvt Ltd, Mumbai, India	Lab.Grade
6	Magnesium stearate	Polymer	Merck Specialities Pvt Ltd, Mumbai, India	Lab.Grade
7	Micro crystalline cellulose	Diluent	Merck Specialities Pvt Ltd, Mumbai, India	Lab.Grade
8	Talc	Polymer	Merck Specialities Pvt Ltd, Mumbai, India	Lab.Grade

Table 2: List of Equipment's used

S.no	Name of the Equipment	Manufacturer	Specification
1	Weighing Balance	Sartorius	IP
2	Tablet Compression Machine (Multistation)	Cemach Limited, India.	IP
3	Hardness tester	Sisco, Mumbai, India.	IP
4	Vernier callipers	Mitutoyo, Japan.	IP
5	Roche Friabilator	Labindia, Mumbai, India	IP
6	Dissolution Apparatus	Labindia, Mumbai, India	IP
7	UV-Visible Spectrophotometer	Labindia, Mumbai, India	IP
8	pH meter	Labindia, Mumbai, India	IP
9	FT-IR Spectrophotometer	Per kin Elmer, United States of America.	IP

Analytical method development:

Determination of absorption maxima:

A solution of containing the concentration 10 µg/ ml was prepared in 0.1N HCl, 7.4 pH & phosphate buffer 6.8pH respectively, UV spectrum was taken using Double beam UV/VIS spectrophotometer. The solution was scanned in the range of 200 – 400.

Preparation calibration curve:

10mg of drug was accurately weighed and dissolved in 10ml of 0.1N HCl, 7.4 PH, and 6.8 PH in 10 ml volumetric flask, to make (1000 µg/ml) standard stock solution (1). Then 1 ml stock solution (1) was taken in another 10 ml volumetric flask to make (100 µg/ml) standard stock solution (2), then again 1 ml of stock solution (2) was taken in another 10 ml volumetric flask and then final concentrations were prepared 2, 4,6, 8, 10, 12, 14, 16, 18 ,and 20µg/ml with 0.1N HCl, 7.4 pH, and 6.8 pH. The absorbance of standard solution was determined using UV/ VIS spectrophotometer at 273nm. Linearity of standard curve was assessed from the square of correlation coefficient (r²) which determined by least-square

linear regression analysis.

Drug – Excipient compatibility studies

Fourier Transform Infrared (FTIR) spectroscopy:

The physical properties of the physical mixture were compared with those of plain drug. Samples was mixed thoroughly with 100mg potassium bromide IR powder and compacted under vacuum at a pressure of about 12 psi for 3 minutes. The resultant disc was mounted in a suitable holder in Perkin Elmer IR spectrophotometer and the IR spectrum was recorded from 3500 cm to 500 cm. The resultant spectrum was compared for any spectrum changes.

Preformulation parameters

The quality of tablet, once formulated by rule, is generally dictated by the quality of physicochemical properties of blends. There are many formulations and process variables involved in mixing and all these can affect the characteristics of blends produced. The various characteristics of blends tested as per Pharmacopoeia.

Angle of repose: The frictional force in a loose powder can be measured by the angle of repose. It is defined as, the

maximum angle possible between the surface of the pile of the powder and the horizontal plane. If more powder is added to the pile, it slides down the sides of the pile until the mutual friction of the particles producing a surface angle, is in equilibrium with the gravitational force. The fixed funnel method was employed to measure the angle of repose. A funnel was secured with its tip at a given height (h), above a graph paper that is placed on a flat horizontal surface. The blend was carefully pored through the funnel until the apex of the conical pile just touches the tip of the funnel. The radius (r) of the base of the conical pile was measured. The angle of repose was calculated using the following formula:

$\tan \theta = h / r$ $\tan \theta =$ Angle of repose
h = Height of the cone, r = Radius of the cone base

Bulk density:

Density is defined as weight per unit volume. Bulk density, is defined as the mass of the powder divided by the bulk volume and is expressed as gm/cm³. The bulk density of a powder primarily depends on particle size distribution, particle shape and the tendency of particles to adhere together. Bulk density is very important in the size of containers needed for handling, shipping, and storage of raw material and blend. It is also important in size blending equipment. 10 gm powder blend was sieved and introduced into a dry 20 ml cylinder, without compacting. The powder was carefully leveled without compacting and the unsettled apparent volume, V_o, was read.

The bulk density was calculated using the formula:

$$\text{Bulk Density} = M / V_o$$

Where, M = weight of sample

V_o = apparent volume of powder

Tapped density:

After carrying out the procedure as given in the measurement of bulk density the cylinder containing the sample was tapped using a suitable mechanical tapped density tester that provides 100 drops per minute and this was repeated until difference between succeeding measurement is less than 2 % and then tapped volume, V measured, to the nearest graduated unit. The tapped density was calculated, in gm per L, using the formula:

$$\text{Tap} = M / V$$

Where, Tap= Tapped Density

M = Weight of sample

V= Tapped volume of powder

Measures of powder compressibility:

The Compressibility Index (Carr's Index) is a measure of the propensity of a powder to be compressed. It is determined from the bulk and tapped densities. In theory, the less compressible a material the more flowable it is. As such, it is measures of the relative importance of interparticulate interactions. In a free- flowing powder, such interactions are generally less significant, and the bulk and tapped densities will be closer in value. For poorer flowing materials, there are frequently greater interparticle interactions, and a greater difference between the bulk and tapped densities will be observed. These differences are reflected in the Compressibility Index which is calculated using the following formulas:

$$\text{Carr's Index} = [(\text{tap} - b) / \text{tap}] \times 100$$

Where, b = Bulk Density

Tap = Tapped Density

Formulation development of Tablets:

Ciprofloxacin colon targeted tablets were prepared by using compression coating technology. Initially internal core tablet containing drug and super disintegrate was formulated. For the prepared core tablet compression coating is done by using various compositions of polymers. Ethyl cellulose, Polymethacrylate polymers such as Eudragit L100 and Eudragit S100 are used as polymers for compression coating.

Tablets are developed in two stages

- 1) Preparation of core tablet containing drug and super disintegrate.
- 2) Compression coating of prepared core tablets.

Formulation of core tablet:

The core tablets are formulated by using 250 mg of drug molecule, sodium starch glycollate as super disintegrate, Micro crystalline cellulose as diluent, talc and magnesium stearate as Glidant and Lubricant respectively. The composition of core tablet was given in below table.

Composition of core tablet

Total weight of core tablet was fixed as 400 mg. The tablets are prepared by using 9mm flat punch. Then the prepared core tablets are subjected to compression coating by using various compositions of polymers.

Formulation of compression coated tablets:

The prepared core tablets were subjected to compression coating by using various compositions of polymers such as Ethyl cellulose, Eudragit L 100 and Eudragit S 100 as coating materials.the composition of coating layer is given in below table.

Composition of coating layer

Compression coating layer was divided into two equal portions i.e., 50mg of each quantity .Half of the quantity of powder blend was placed in the die cavity, core tablet was placed exactly in the middle of die cavity and then remaining quantity of powder blend was placed over the core tablet so that the powder blend should cover all the sides and top side of core tablet uniformly. Then the tablets are compressed by using 10mm flat surfaced punch using 8 station tablet punching machine with the hardness of 4-4.5 kg/cm².Then the prepared compression coted tablets are evaluated for various post compression parameters as per standard specifications.

Evaluation of post compression parameters for prepared Tablets:

The designed formulation compression coated tablets were studied for their physicochemical properties like weight variation, hardness, thickness, friability and drug content.

Weight variation test:

To study the weight variation, twenty tablets were taken and their weight was determined individually and collectively on a digital weighing balance. The average weight of one tablet was determined from the collective weight. The weight variation test would be a satisfactory method of determining the drug content uniformity. Not more than two of the individual weights deviate from the average weight by more than the percentage shown in the following table and none deviate by more than twice the percentage. The mean and deviation were determined. The percent deviation was calculated using the following formula.

% Deviation = (Individual weight – Average weight / Average weight) × 100

Hardness:

Hardness of tablet is defined as the force applied across the diameter of the tablet in order to break the tablet. The resistance of the tablet to chipping, abrasion or breakage under condition of storage transformation and handling before usage depends on its hardness. For each formulation, the hardness of three tablets was determined using Monsanto hardness tester and the average is calculated and presented with deviation.

Thickness: Tablet thickness is an important characteristic in reproducing appearance. Tablet thickness is an important characteristic in reproducing appearance. Average thickness for core and coated tablets is calculated and presented with deviation.

Friability: It is measured of mechanical strength of tablets. Roche friabilator was used to determine the friability by following procedure. Preweighed tablets were placed in the friabilator. The tablets were rotated at 25 rpm for 4 minutes (100 rotations). At the end of test, the tablets were re weighed, loss in the weight of tablet is the measure of friability and is expressed in percentage as

$$\% \text{ Friability} = [(W1 - W2) / W] \times 100$$

Where, W1 = Initial weight of three tablets

W2 = Weight of the three tablets after testing

Determination of drug content:

Both compression-coated tablets of were tested for their drug content. Ten tablets were finely powdered quantities of the powder equivalent to one tablet weight of Ciprofloxacin were accurately weighed, transferred to a 100 ml volumetric flask containing 50 ml water and were allowed to stand to ensure complete solubility of the drug. The mixture was made up to volume with water. The solution was suitably diluted and the absorption was determined by UV –Visible spectrophotometer. The drug concentration was calculated from the calibration curve.

In vitro drug release studies

Drug release studies of Ciprofloxacin core tablets:

The core tablets containing 15mg Ciprofloxacin of were tested in (pH 6.8), for their dissolution rates. Dissolution studies were performed using USP paddle type sample of 5 ml was withdrawn and replaced with equal volume of fresh medium. The samples were analyzed spectrophotometrically at respective 270 nm.

Drug release studies of compression coated Ciprofloxacin tablets:

The release of Ciprofloxacin from coated tablets was carried out using USP paddle-type dissolution apparatus at a rotation speed of 50 rpm, and a temperature of 37±0.5 °C. For tablets, simulation of gastrointestinal transit conditions was achieved by using different dissolution media. Thus, drug release studies were conducted in simulated gastric fluid (SGF, pH 1.2) for the first 2 hours as the average gastric emptying time is about 2 hours. Then, the dissolution medium was replaced with enzyme- free simulated intestinal fluid (SIF, pH 7.4) and tested for drug release for 3 hours, as the average small intestinal transit time is about 3 hours, and finally enzyme-free simulated intestinal fluid (SIF, pH 6.8) was used up to 12 hours to mimic colonic pH conditions. Drug release was measured from compression coated Ciprofloxacin tablets,

added to 900 ml of dissolution medium. 5 ml of sample was withdrawn every time and replaced with fresh medium, samples withdrawn at various time intervals were analyzed spectrophotometrically at 275 nm and 270 nm respectively. All dissolution runs were performed for six batch. The results were given with deviation.

Application of Release Rate Kinetics to Dissolution Data various models were tested for explaining the kinetics of drug release. To analyze the mechanism of the drug release rate kinetics of the dosage form, the obtained data were fitted into zero-order, first order, Higuchi, and Korsmeyer-Peppas release model.

Zero order release rate kinetics:

To study the zero-order release kinetics the release rate data are fitted to the following equation.

$$F = K_0 t$$

Where, 'F' is the drug release at time 't', and 'K₀' is the zero order release rate constant. The plot of % drug release versus time is linear.

First order release rate kinetics: The release rate data are fitted to the following equation

$$\text{Log}(100 - F) = kt$$

A plot of log cumulative percent of drug remaining to be released vs. time is plotted then it gives first order release.

Higuchi release model: To study the Higuchi release kinetics, the release rate data were fitted to the following equation.

$$F = k t^{1/2}$$

Where, 'k' is the Higuchi constant.

In higuchi model, a plot of % drug release versus square root of time is linear.

Korsmeyer and Peppas release model:

The mechanism of drug release was evaluated by plotting the log percentage of drug released versus log time according to Korsmeyer- Peppas equation. The exponent 'n' indicates the mechanism of drug release calculated through the slope of the straight Line.

$$M_t / M_\infty = K t^n$$

Where, M_t / M_∞ is fraction of drug released at time 't', k represents a constant, and 'n' is the diffusional exponent, which characterizes the type of release mechanism during the dissolution process. For non-Fickian release, the value of n falls between 0.5 and 1.0; while in case of Fickian diffusion, n = 0.5; for zero-order release (case I I transport), n=1; and for supercase II transport, n > 1. In this model, a plot of log (M_t / M_∞) versus log (time) is linear.

Hixson-Crowell release model:

$$(100 - Q_t)^{1/3} = 100^{1/3} - K_{HC} t$$

Where, k is the Hixson-Crowell rate constant.

Hixson-Crowell model describes the release of drugs from an insoluble matrix through mainly erosion. (Where there is a change in surface area and diameter of particles or tablets).

3. Results and Discussion

The present study was aimed to developing compression coated Ciprofloxacin formulations for colon targeting using ethyl cellulose and enteric coating polymers like Eudragit L100 and Eudragit S 100. All the formulations were evaluated for physicochemical properties and invitro drug release studies.

Table 3: Observations for graph of Ciprofloxacin in 0.1N HCl (275 nm)

S.No.	Conc [mg/l]	ABS
1	1	0.001
2	3	0.075
3	4	0.128
4	5	0.199
5	6	0.280
6	7	0.343
7	8	0.397
9	11	0.557
10	12	0.623
13	21	0.823
14	22	0.87

Figure 4: Standard graph of Ciprofloxacin in 6.8 pH

S.No.	Conc [mg/l]	ABS
1	1	0.001
2	2	0.043
3	4	0.131
4	5	0.185
5	6	0.252
6	7	0.309
7	8	0.371
9	9	0.430
10	10	0.504
13	13	0.684
14	14	0.740
15	15	0.799
16	16	0.896

Ciprofloxacin blend was subjected to various pre-formulation parameters. The apparent bulk density and tapped bulk density values ranged from 0.52 to 0.581 and 0.606 to 0.671 respectively. According to Tables 7.4, the results of angle of repose and compressibility index (%) ranged from 32.74 ± 0.12 to 37.08 ± 0.96 and 13.37 ± 0.38 to 14.72 ± 0.62 respectively. The results of angle of repose (<35) and compressibility index (<23) indicates fair to passable flow properties of the powder mixture. These results show that the powder mixture has good flow properties. The formulation blend was directly compressed to tablets and *in-vitro* drug release studies were performed.

Quality Control Parameters For compression coted tablets: Tablet quality control tests such as weight variation, hardness, and friability, thickness, and drug release studies in different media were performed on the compression coated tablet. Total weight of tablet including core is 300 mg.

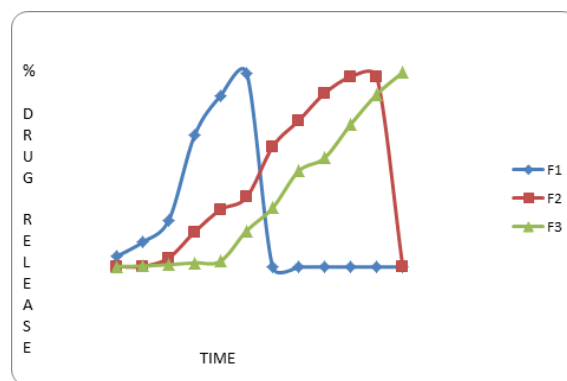
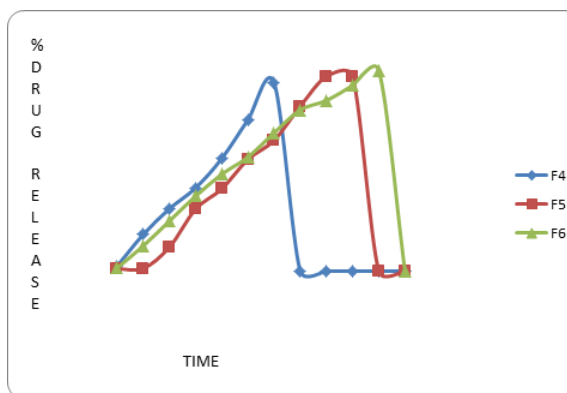
In-Vitro Drug Release Studies

The compression coated tablets containing 250mg of Ciprofloxacin were tested in 6.8 pH phosphate buffer solution for their dissolution rates. The release of Ciprofloxacin from compression coated tablets was carried out using USP paddle-type dissolution apparatus at a rotation speed of 50 rpm, and a temperature of 37 ± 0.5 °C. For tablets, simulation of gastrointestinal transit conditions was achieved by using different dissolution media. Thus, drug release studies were conducted in simulated gastric

fluid (SGF, pH 1.2) for the first 2 hours as the average gastric emptying time is about 2 hours. Then, the dissolution medium was replaced with enzyme- free simulated intestinal fluid (SIF, pH 7.4) and tested for drug release for 3 hours, as the average small intestinal transit time is about 3 hours, and finally enzyme- free simulated intestinal fluid (SIF, pH 6.8) was used upto 12 hours to mimic colonic pH conditions.

Drug release was measured from compression coated Ciprofloxacin tablets, added to 900 ml of dissolution medium. 5 ml of sample was withdrawn every time and replaced with fresh medium, samples withdrawn at various time intervals were analyzed spectrophotometrically at 275 nm, 319 and 320 nm respectively. All dissolution runs were performed for six batches.

From the dissolution values it was evident that the formulations F3 & F9 were retarded the drug release up to 12 hours, they shown drug release of 98.69 and 96.45 % respectively. Formulations F1 –F3 contains ethyl cellulose alone. As the concentration of ethyl cellulose increases retardation nature was increased. F3 formulation containing 150 mg of ethyl cellulose was show almost negligible amount of drug release in first 3 hours from the 5th hour onwards it shown drug release as the time proceeds slowly the polymer was undergone erosion and allowed the drug to come out from the dosage form. The formulation was retarded drug release up to 12 hours and it showed maximum drug release in 12 hours i.e., in colon region. Similarly the formulation F9 containing Eudragit L 100 in the concentration of 150 mg also showed similar drug release pattern.

**Fig.2:** Dissolution of formulations F1-F3**Fig.3:** Dissolution of formulations F4-F6

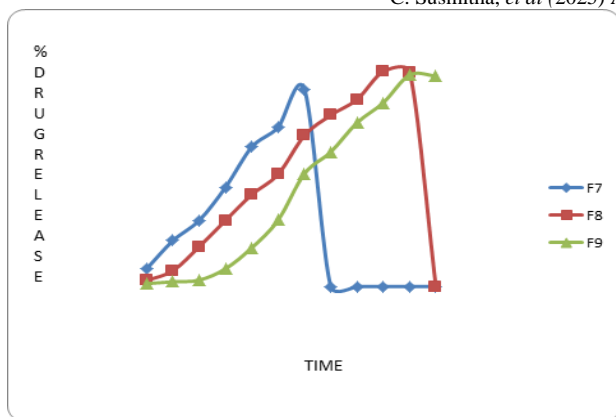


Fig.4: Dissolution of formulations F7-F9

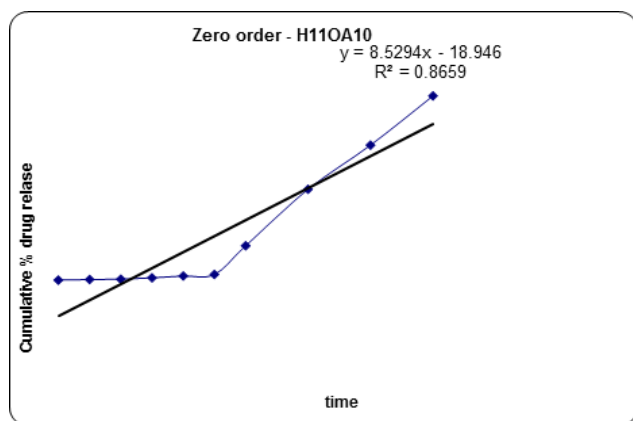


Fig.5: Zero order release kinetics graph

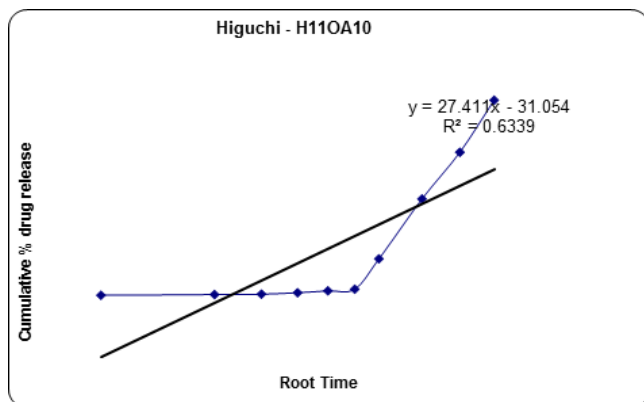


Fig.6: Higuchi release kinetics graph

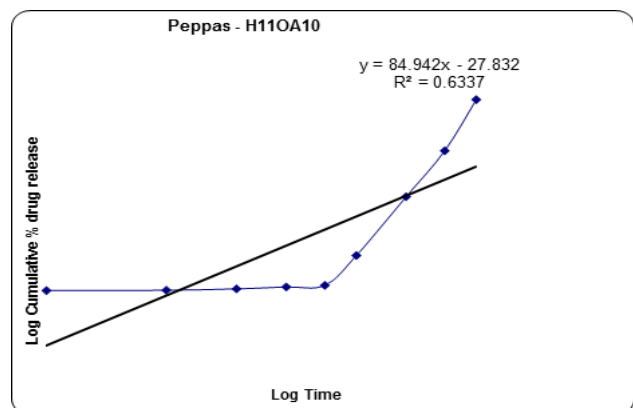


Fig.7: Kars mayer peppas graph

4. Conclusion

In the present research work sustained release matrix formulation of Ciprofloxacin targeted to colon by using various polymers developed. To achieve pH-independent drug release of Ciprofloxacin, pH modifying agents (buffering agents) were used. Colon targeted tablets were prepared in two steps. Initially core tablets were prepared and then the tablets were coated by using different pH dependent polymers. Ethyl cellulose, Eudragit L100 and S100 were used as enteric coating polymers. The precompression blend of all formulations was subjected to various flow property tests and all the formulations were passed the tests. The tablets were coated by using polymers and the coated tablets were subjected to various evaluation techniques. The tablets were passed all the tests. Among all the formulations F3 formulation was found to be optimized as it was retarded the drug release up to 12 hours and showed maximum of 98.69% drug release. It followed zero order kinetics mechanism.

5. References

- [1] Mortazavi, Seyed Alireza, Zahra Jaffariazar, and Elnaz Damercheli. Formulation and in-vitro evaluation of ocular ciprofloxacin-containing minitables prepared with different combinations of carbopol 974P and various cellulose derivatives. *Iranian Journal of Pharmaceutical Research: IJPR*. 2010; 9(2): 107.
- [2] Mostafavi, Abolfazl, et al. Development of a prolonged-release gastroretentive tablet formulation of ciprofloxacin hydrochloride: Pharmacokinetic characterization in healthy human volunteers. *International journal of pharmaceutics*. 2011; 1(2): 128-136.
- [3] Reddy, V. Sarovar. Formulation and evaluation of floating tablets of ciprofloxacin hydrochloride. *Asian Journal of Pharmaceutics*. 2018; 12(2); 106-114.
- [4] Arza, Ramji Anil Kumar, Chandra Sekhara Rao Gonugunta, and Prabhakar Reddy Veerareddy. "Formulation and evaluation of swellable and floating gastroretentive ciprofloxacin hydrochloride tablets. *AAPs Pharmsci Tech*. 2009; 10: 220-226.
- [5] Kasgavade, Prasad, and M. Swapnil. "Formulation and evaluation of fast dissolving tablet of Ciprofloxacin." *Int J Adv Pharm*. 2016; 5: 52-60.
- [6] Jaman, M., et al. "In vitro evaluation of Ciprofloxacin Hydrochloride." *Bangladesh Journal of Scientific and Industrial Research*. 2015; 50(4): 251-256.
- [7] Venkateswarlu, Kambham. Formulation development and in-vitro evaluation of floating tablets of ciprofloxacin HCl. *Asian Journal of Pharmaceutics (AJP)* 10.04 (2016).
- [8] Kumar, Kar Ayan, et al. "Design, formulation and evaluation of sustained release bilayer tablets of ciprofloxacin hydrochloride." *Journal of Drug Delivery & Therapeutics*. 2019; 9(1): 46-53.
- [9] Olivera, Maria Eugenia, et al. "Biowaiver monographs for immediate release solid oral

dosage forms Ciprofloxacin
hydrochloride. Journal of pharmaceutical
sciences. 2011; 100(1): 22-33.

- [10] Masaad, Ahmed MA, et al. "Improvement in the Characters of a newly formulated Effervescent Ciprofloxacin Tablets by Enhancement in the Excipient Properties of the Formula." *Int. J. Curr. Res. Chem. Pharm. Sci.*, 2016; 3(10): 58-64.