Research Article

DESIGN AND OPTIMIZATION OF CEFIXIME TRIHYDRATE SUSTAINED RELEASE MATRIX TABLETS USING DIFFERENT POLYMERS

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ABSTRACT

The objective of the present work is to design sustained release matrix tablets of Cefixime Trihydrate by incorporating drug in a matrix made up of release retardant polymers, which prolongs the drug release leading to minimize the peak and valley effect in the plasma and provide patient convenience. The effect of combination of polymers on parameters like release pattern, release mechanism of the drug were studied. Total nine formulations each containing 200 mg of drug were prepared by direct compression method. The formulations F-1, F-2, F-3 were prepared 1:1 drug to polymer ratio using HPMC, sodium CMC and Ethyl cellulose. F-4 was prepared by 1:1 ratio of HPMC and sodium CMC, F-5 was prepared by 1:1 ratio of HPMC and Ethyl cellulose, F-6 was prepared by 1:1 ratio of sodium CMC and Ethyl cellulose, F-7, F-8, F-9 were prepared by using polymers HPMC, sodium CMC and Ethyl cellulose in the ratios of (0.5:0.5:1), (0.5:1:0.5), (1:0.5:0.5). Designed matrix tablets evaluated for various pre-compression and post-compression parameters. Formulation F-5(1:1 ratio of HPMC and Ethylcellulose) showed 102.15 % release at the end of 12 hours and it is selected as the best formulation. All Formulations follows zero order with non-fickian diffusion method.

Keywords: sustained release, patient compliance, HPMC, Sod CMC, Ethyl cellulose.

INTRODUCTION

The infectious diseases are most common in developing countries. The infectious bacterial classes are both Gram⁺ and Gram⁻ hence, the treatment is necessary with an agent, which have broad spectrum of activity. Cephalosporins possess a wide range of activity against Gram⁺ and Gram⁻ bacteria; these are act by inhibiting bacterial cell wall synthesis. Cefixime Trihydrate is an orally active third generation cephalosporin^{1,2}. Sustained release dosage forms have number of advantages over conventional dosage forms, improved patient convenience due to less frequent dosing, reduction in fluctuation in steady-state levels and therefore better control of disease, maximum utilization of drug enabling reduction in total amount of dose administered³⁻⁵. The objectives of the present work are to design, formulate and evaluate matrix tablets of Cefixime Trihydrate for sustained release dosage form. As the effect of sustained release dosage form is relatively more, incorporating the drug in the matrix tablet will prolong the drug release. These are prepared by direct compression method. The matrix tablets of Cefixime Trihydrate designed using polymers such as HPMC K5M, sodium CMC and Ethyl cellulose and evaluated for various pre-compression and post-compression parameters^{6,7}. The effect of combination of HPMC K5M and EC, HPMC and sodium CMC, EC and sodium CMC, HPMC EC sodium CMC on response parameters like release pattern, cumulative percent release of the drug, drug release mechanism were studied.

MATERIALS AND METHODS

Cefixime Trihydrate, Micro crystalline cellulose purchased from K.A.P.L., Bangalore [India], HPMC K5M, Ethyl cellulose and Sodium CMC purchased from Colorcon Asia Pvt. Ltd, Magnesium Stearate purchased from Loba Chemie Pvt. Ltd, Sodium Hydroxide, hydrochloric acid purchased from [Sd Fine Chem. Limited, Mumbai, India], Potassium dihydrogen ortho-phosphate [Ranbaxy Fine Chemicals].

Fourier Transform Infrared (FTIR) Spectroscopy

The Fourier transform infrared (FTIR) spectra of samples were obtained using FTIR spectrophotometer (Perkin Elmer). Pure drug, individual polymers and optimized formulations were subjected to FTIR study. About 2–3 mg of sample was mixed with dried potassium bromide of equal weight and compressed to form a KBr disk. The samples were scanned from 500 to 4000 cm⁻¹.

Formulation of sustained release matrix tablets

Sustained release matrix tablets were prepared by direct compression method as per the formula given in the Table 7. Initially the drug was passed through the sieve no 30, all the polymers were passed through the sieve no 40 and microcrystalline cellulose and magnesium stearate were passed through the sieve no 60. Required quantity of drugs polymers and diluents were mixed thoroughly. This powder mixture was blended and compressed using single punch tableting machine with hardness of the tablets maintained between 8-11 kg/cm².

Evaluation

Pre-compression evaluation Parameters

- Bulk density and Tapped density: Bulk density is the ratio of total mass of powder to the bulk volume of powder. It was measured by pouring the weighed powder (passed through standard sieve # 20) into a measuring cylinder and the initial volume (bulk volume) was noted. From this, the bulk density is calculated. Tapped density is the ratio of total mass of powder to the tapped volume of powder. It was measured by pouring the weighed powder into a measuring cylinder and then it was subjected to 500 tapings from a height of 2 inches. The volume was measured, tapped density is calculated. Three determinations were done for each formula¹⁰.
- Hausners Ratio and Compressibility index or Carr's index (%): Hausner's ratio is the ratio of tapped density to bulk

density. It was measured by pouring the weighed powder into a measuring cylinder and the initial volume was noted and then it was subjected to 500 tapings from a height of 2 inches. Hauser's ratio was calculated by noted tapped density and poured density values. Carr's index was calculated as 100 times the ratio of the difference between tapped density and bulk density to the tapped density. It was measured by calculated tapped density and poured density values. Three determinations were carried out in triplicate¹⁰.

- Angle of repose (θ): It is defined as the maximum angle possible between the surface of a pile of powder and the horizontal plane; it was measured by pouring the weighed powder mixture into the funnel which was fixed to stand at a definite height (h). The drug excipient blend was allowed to flow through the Funnel freely on to the surface and placed on a graph sheet. Then the height and diameter of the heap formed were noted down, angle of repose was calculated. Three determinations were performed¹¹. It can be calculated using the formula,

$$\tan \theta = h/r$$

Where, h = Height, r = Radius, θ = Angle of repose

Post compression evaluation for formulated matrix tablets

- Hardness: Hardness or tablet crushing strength is the force required to break a tablet in a diametric compression. Hardness of the tablet was determined using the Monsanto hardness tester (Shreeji Chemicals). The hardness was computed by deducting the initial pressure from the final pressure. Test was performed on six tablets and average was calculated¹².
- Weight variation: Twenty tablets were selected randomly from each batch and determine average weight. Compare the average weight with individual weight¹².
- Thickness: tablets thickness was measured using a vernier-calliper, take the average of randomly selected three tablets¹².
- Drug content uniformity: Randomly selected ten tablets were weighed and average weight of a tablet calculated. Tablets were ground individually to fine powder. Powder equivalent to 280 mg of Cefixime Trihydrate was transferred to 100 ml volumetric flask, dissolved in 80 ml of pH 7.2 buffer. Then the volume was made up to 100 ml with buffer and filtered through whattman filter paper. Absorbance of the sample solution was measured using UV-visible spectrophotometer, and concentration of the drug in the sample was calculated¹².
- Friability Test: The friability was determined using Roche Friability test apparatus. It is expressed in percentage (%). Ten tablets were initially weighed and transferred into the device. It was operated at 25 rpm for run up to 100 revolutions. The tablets were weighed again. The % friability was then calculated by the formula,

$$F = \frac{\text{Initial weight of Tablets} - \text{Final weight of the tablets}}{\text{Initial weight of the tablets}} \times 100$$

% friability of tablets less than 1 % is considered acceptable

- *In-vitro* Release studies

In vitro dissolution of sustained release tablets of Cefixime Trihydrate was studied in USP XXIII dissolution apparatus

(Electro lab) rotated at 100 rpm. 900 ml of standard buffer pH 1.2 for two hours, followed by pH 7.2 for the next 10 hours were used as dissolution medium. The temperature of dissolution medium was maintained at $37 \pm 0.5^\circ\text{C}$ throughout the experiment. One tablet was used in each test. Samples of dissolution medium (5 ml) were withdrawn by means of syringe fitted with pre-filter at known intervals of time and analyzed for drug release by measuring the absorbance at 288 nm. The volume withdrawn at each time interval was replaced with fresh quantity of dissolution medium. The dissolution studies were carried out in triplicate. Cumulative percent drug released was calculated and plotted against time¹².

Dissolution test parameters for sustained release tablets of Cefixime Trihydrate

Medium : 900 ml of 7.2.pH phosphate buffer
Rpm : 100
Time : 60 minutes interval.
 λ_{max} : 288 nm
Temperature : $37^\circ\text{C} \pm 0.5^\circ\text{C}$

- *In-vitro* Release kinetics

Dissolution data of above formulations was fitted in Zero order, First order equations.

Zero-Order Kinetics

Zero order as cumulative amount of drug released vs. time,

$$C = K_0 t$$

Where K_0 is the zero-order rate constant expressed in units of concentration/time and t is the time in hours

A graph of concentration vs. time would yield a straight line with a slope equal to K_0 and intercept the origin of the axes¹³.

First order kinetics

First order as log cumulative percentage of drug remaining vs. time,

$$\log C = \log C_0 - kt / 2.303$$

Where C_0 is the initial concentration of drug, k is the first order constant, and t is the time¹³

Higuchi Model

Higuchi's model as cumulative percentage of drug released vs. square root of time

$$Q = K t_{1/2}$$

Where K is the constant reflecting the design variables of the system and t is the time in hours

Hence, drug release rate is proportional to the reciprocal of the square root of time¹⁴.

Korsmeyer Peppas equations

To evaluate the mechanism of drug release from dosage form, data for the first 60 % of drug release were plotted in Korsmeyer *et al*'s equation log cumulative percentage of drug released vs. log time, and the exponent n was calculated through the slope of the straight line.

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

Where M_t/M_∞ is the fractional solute release, t is the release time, K is a kinetic constant characteristic of the drug/polymer system, and n is an exponent that characterizes the mechanism of release of tracers

For cylindrical matrix tablets, if the exponent $n = 0.45$, then the drug release mechanism is Fickian diffusion, and if $0.45 < n < 0.89$, then it is non-Fickian or anomalous diffusion. An exponent value of 0.89 is indicative of Case-II Transport or typical zero-order release¹⁵.

RESULTS AND DISCUSSION

Infrared Spectroscopy Studies (I.R.)

I.R. spectrum of Cefixime Trihydrate pure, physical mixtures of drug, excipients and the polymers were taken. The characteristics peaks of Cefixime Trihydrate are obtained at 3564.72 cm^{-1} , 3293.56 cm^{-1} , 1777.21 cm^{-1} , 1677.30 cm^{-1} , 1588.11 cm^{-1} , 1581.17 cm^{-1} , 1184.94 cm^{-1} , 1224.18 cm^{-1} , 803.17 cm^{-1} , 863.83 cm^{-1} and 746.09 cm^{-1} . The I.R. spectra's obtained indicates good compatibility between drug and excipients. All the spectra's are shown in the Figure 1 to 5.

Pre - compression evaluation of powder mixture

- Bulk density and Tapped density: The bulk densities of the powder blends of all the formulations ranged from 0.255 to 0.414 g/cc. The Tapped densities of the powder blends of all the formulations ranged from 0.274 to 0.453 gm/cc. (Table 2)
- Hausners Ratio and Compressibility index or Carr's index (%): The Hausners ratio values ranged from 1.057 to 1.25. Evaluated values were Less than 1.25 Indicating Good flow. It means that the powder flow properties were within the pharmacopoeias limits. The Carr's index values ranged from 5.86 to 10 %. 5-15 Carr's index value indicates excellent flow. It means that the powder flow properties were within the pharmacopoeias limits (Table 2).
- Angle of repose (θ): It is defined as maximum angle possible between the surface of the pile of powder and the horizontal plane. Values ranged from 28.17° to 34.36° angle of repose (< 35) indicate good flow properties of granules, and it was observed to be within the pharmacopoeias limits (Table 2).

Post compression evaluation for formulated Matrix tablets

Hardness

The hardness of all the formulations ranged from 2.7 to 3.3 kg/cm^2 . The pharmacopoeias limit for hardness is 3-5 kg/cm^2 . Hence all the formulations passed the test for hardness (Table 3).

Weight variation

The weights of the tablets were between 500 to 504 mg, as the weight of the tablet is 500 mg, the weight variation limit is $\pm 5\%$. The pharmacopoeias specification for weight variation limit is $\pm 5\%$, for uncoated tablets weighing more than 324 mg. Hence all the formulations passed the weight variation test (Table 3).

Thickness

The thickness of all the formulations was between 2.73 to 3.1 mm which was according to the pharmacopoeias specifications. Tablet mean thickness was almost uniform in all the formulations (Table 3).

Friability

The friability of all the formulations was determined, and the values were in the range from 0.39 to 0.56 %. Friability below 1 % was an indication of good mechanical resistance

of the tablets. Hence all the formulations were within the pharmacopoeias limits (Table 3).

Drug content uniformity

The percentage drug content of both the drugs in all the formulated tablets was found to be within limit. Percentage drug content values of Cefixime Trihydrate are within 98.21 to 102.5 % for all the nine formulations. The results within range indicate uniformity of mixing. Table 10 shows all values of drug content uniformity (Table 3).

In-vitro Release studies

The results obtained in the *in-vitro* drug release for different formulations are shown in Table 4. The results of dissolution studies indicated that formulations F-1 releases 99 % of Cefixime Trihydrate at the 9th hour, F-2 releases 101.44 % at the 6th hour, F-3 releases 99.8 % of drug at the 11th hour, F-4 releases 101.75 % at the 9th hour, F-5 releases 102.15 % at the 12th hour, F-6 releases 100.99 % at the 11th hour, F-7 release 99.89 % at the 11th hour, F-8 release 99.78 % at the 9th hour, Formulation F-9 releases 100.97 % of drug at the 9th hour. Results were plotted in Figure 6. From the data and graphs obtained, it was concluded that the formulation F-5 (HPMC: EC in 1:1 ratio) released 102.15 % release of Cefixime Trihydrate in 12 h was selected as the best formulations.

In-vitro release kinetics

To know the mechanism of drug release from these formulations, data was processed for regression analysis using MS-Excel statistical functions. The data were treated according to zero order, first-order, Higuchi's, and Korsmeyer Peppas's equations. According to the zero-order equation (Figure 7-8), formulations showed fair linearity with regression values between 0.956 and 0.999, first-order equation (Figure 9-10) gives regression values between 0.819 and 0.961, from the data it shows that the formulations (F1-F9) follows zero-order release pattern (Table 5). Diffusion mechanism involved in the release of the drug from the tablets, as the Higuchi's plots (Figure 11, 12) showed high linearity with regression values between 0.973 and 0.991. Non-Fickian diffusion involved in formulations (F1-F9) as the Korsmeyer Peppas plots (Figure 13, 14) slope (n) values ranging from 0.527 to 0.630, (Table 6).

CONCLUSION

Different polymers such as HPMC, MC, and Sod CMC were used in different ratios for the preparation of Cefixime Trihydrate matrix tablets. Formulations F1, F2, F3 were prepared using polymers HPMC, sodium CMC and Ethyl cellulose respectively on the basis of 1:1 drug to polymer ratio. F-4 was prepared by 1:1 ratio of HPMC and sodium CMC, F-5 was prepared by 1:1 ratio of HPMC and Ethylcellulose, F-6 was prepared by 1:1 ratio of sodium CMC and Ethyl cellulose. Further, three formulations (F7, F8, F9) were prepared by using polymers HPMC, sodium CMC and Ethyl cellulose in the ratios of 0.5:0.5:1, 0.5:1:0.5, 1:0.5:0.5. FT-IR spectrums were carried, and all the spectra were compared, there is no interaction between drug and polymer. Tablets were evaluated for weight variation and thickness, drug content, *in vitro* dissolution. When compared to all the nine formulations, formulation F-5 (HPMC: EC in 1:1 ratio) released 102.15 % release of Cefixime Trihydrate in 12 h was selected as the optimized formulations. All the formulations follow zero order release kinetics with diffusive mechanism by non Fickian.

Table 1: Composition of Tablet Formulations

S. NO	FORMULATION CODE	QTY OF DRUG	HPMC	SOD.CMC	E.C	MCC	MAGNESIUM STEARATE	TOTAL
1	F-1	200	200	-	-	95	5	500
2	F-2	200	-	200	-	95	5	500
3	F-3	200	-	-	200	95	5	500
4	F-4	200	100	100	-	95	5	500
5	F-5	200	100	-	100	95	5	500
6	F-6	200	-	100	100	95	5	500
7	F-7	200	50	50	100	95	5	500
8	F-8	200	50	100	50	95	5	500
9	F-9	200	100	50	50	95	5	500

HPMC is hydroxy propyl methyl cellulose, Sod CMC is sodium carboxy methyl cellulose, EC is ethyl cellulose, and MCC is micro crystalline cellulose

Table 2: Pre compression Parameters of the Powder Mixture

Formulation Code	Bulk Density (g/ml) Mean $\pm$ s. d. (n = 3)	Tapped density (g/ml) Mean $\pm$ s. d. (n = 3)	Compressibility index (%) mean $\pm$ s. d. (n = 3)	Hausners ratio mean $\pm$ s. d. (n = 3)	Angle of repose
F-1	0.273 $\pm$ 0.001	0.302 $\pm$ 0.001	6.74 $\pm$ 0.04	1.25 $\pm$ 0.03	33.92 ⁰
F-2	0.414 $\pm$ 0.002	0.453 $\pm$ 0.001	10.0 $\pm$ 0.04	1.057 $\pm$ 0.03	34.36 ⁰
F-3	0.333 $\pm$ 0.001	0.345 $\pm$ 0.002	9.27 $\pm$ 0.01	1.22 $\pm$ 0.04	32.31 ⁰
F-4	0.304 $\pm$ 0.002	0.340 $\pm$ 0.001	10.0 $\pm$ 0.02	1.24 $\pm$ 0.01	28.17 ⁰
F-5	0.294 $\pm$ 0.002	0.318 $\pm$ 0.002	7.54 $\pm$ 0.02	1.195 $\pm$ 0.04	32.22 ⁰
F-6	0.304 $\pm$ 0.001	0.327 $\pm$ 0.004	9.27 $\pm$ 0.03	1.23 $\pm$ 0.07	32.73 ⁰
F-7	0.257 $\pm$ 0.001	0.276 $\pm$ 0.003	6.58 $\pm$ 0.01	1.113 $\pm$ 0.06	31.22 ⁰
F-8	0.272 $\pm$ 0.001	0.290 $\pm$ 0.003	5.86 $\pm$ 0.04	1.192 $\pm$ 0.04	34.11 ⁰
F-9	0.255 $\pm$ 0.001	0.274 $\pm$ 0.003	6.56 $\pm$ 0.01	1.25 $\pm$ 0.01	31.81 ⁰

SD is standard deviation for n = 3 observations

Table 3: Evaluation Parameters of the Compressed Tablets

Formulation Code	Thickness (mm) Mean $\pm$ s. d. (n = 3)	Weight variation (mg) Mean $\pm$ s. d. (n = 3)	Hardness (kg/cm ²) Mean $\pm$ s. d. (n = 3)	Friability (%) (n = 3)	Drug Content (%) (n = 3)
F-1	2.92 $\pm$ 0.55	504.20 $\pm$ 3.57	2.7 $\pm$ 0.32	0.42 $\pm$ 0.02	99.61 $\pm$ 0.45
F-2	2.73 $\pm$ 0.24	503.10 $\pm$ 4.25	3.2 $\pm$ 0.33	0.49 $\pm$ 0.01	101.31 $\pm$ 0.25
F-3	2.83 $\pm$ 0.32	504.10 $\pm$ 4.94	3.3 $\pm$ 0.65	0.51 $\pm$ 0.04	99.54 $\pm$ 0.55
F-4	2.9 $\pm$ 0.33	503.20 $\pm$ 5.50	3.28 $\pm$ 0.69	0.40 $\pm$ 0.05	99.79 $\pm$ 0.58
F-5	2.96 $\pm$ 0.85	502.90 $\pm$ 4.59	3.3 $\pm$ 0.58	0.39 $\pm$ 0.03	99.82 $\pm$ 0.54
F-6	2.83 $\pm$ 0.55	505.33 $\pm$ 3.33	2.9 $\pm$ 0.22	0.48 $\pm$ 0.02	99.44 $\pm$ 0.06
F-7	2.94 $\pm$ 0.24	503.10 $\pm$ 4.74	2.8 $\pm$ 0.55	0.56 $\pm$ 0.03	99.31 $\pm$ 0.41
F-8	2.98 $\pm$ 0.63	503.20 $\pm$ 4.04	2.8 $\pm$ 0.51	0.47 $\pm$ 0.02	99.48 $\pm$ 0.52
F-9	3.1 $\pm$ 0.66	503.10 $\pm$ 3.93	3.1 $\pm$ 0.69	0.46 $\pm$ 0.01	100.11 $\pm$ 0.44

SD is standard deviation for n = 3 observations

Table 4: In-vitro Dissolution Profile for Formulations F1-F9

Time (h)	Cumulative Percentage Drug Release (%)								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
1	29.5	38.92	17.61	33.7	23.6	25.19	24.9	32	30.05
2	42.07	52.29	23.92	42.5	30.98	32.16	31.72	41.07	43.01
3	55.04	69.84	32.83	50.45	37.52	40.98	38.78	49.19	56.02
4	70.42	80.74	41.27	61.17	45.89	47.65	46.92	58.98	71.62
5	76.05	92.45	50.45	70.92	53.12	55.21	64.68	69.01	77.18
6	80.24	101.44	58.90	78.27	60.98	62.93	68.95	76.98	81.24
7	89.24	-	67.62	88.19	69.72	72.12	70.08	87.03	90.18
8	94.5	-	75.95	96.91	79.92	84.83	81.98	94.89	95.98
9	99.0	-	83.62	101.75	85.09	88.14	86.38	99.78	100.97
10	-	-	91.9	-	91.15	96.09	92.67	-	-
11	-	-	99.8	-	96.95	100.99	99.89	-	-
12	-	-	-	-	102.15	-	-	-	-

Table 5: Release Kinetics of Formulated Matrix Tablets

Formulation code	Correlation coefficient	
	Zero order	First order
F1	0.956	0.864
F2	0.989	0.961
F3	0.999	0.909
F4	0.996	0.844
F5	0.995	0.860
F6	0.994	0.819
F7	0.980	0.936
F8	0.996	0.889
F9	0.958	0.937

Correlation coefficient values of zero order, first order release

Table 6: Diffusion Characteristics of Formulated Matrix Tablets

Formulation code	Kinetic models		
	Higuchi	Peppas Model	
	R ²	R ²	N
F1	0.993	0.991	0.565
F2	0.996	0.991	0.545
F3	0.949	0.987	0.630
F4	0.989	0.978	0.527
F5	0.973	0.979	0.622
F6	0.969	0.973	0.604
F7	0.975	0.973	0.615
F8	0.988	0.981	0.542
F9	0.994	0.991	0.561

Correlation coefficient value of higuchi, peppas models

Figure 1: Spectra of Cefixime Trihydrate

The characteristics peaks of Cefixime Trihydrate are obtained at 3564.72 cm^{-1} , 3293.56 cm^{-1} , 1777.21 cm^{-1} , 1677.30 cm^{-1} , 1588.11 cm^{-1} , 1581.17 cm^{-1} , 1184.94 cm^{-1} , 1224.18 cm^{-1} , 803.17 cm^{-1} , 863.83 cm^{-1} and 746.09 cm^{-1} .

Figure 2: Spectra of Cefixime Trihydrate with HPMC, MCC

The characteristics peaks of Cefixime Trihydrate are obtained at 3564.72 cm^{-1} , 3293.56 cm^{-1} .

Figure 3: Spectra of Cefixime Trihydrate with EC, MCC

The characteristics peaks of Cefixime Trihydrate are obtained at 3564.72 cm^{-1} , 3293.56 cm^{-1} .

Figure 4: Spectra of Cefixime Trihydrate with sod.CMC, MCC

The characteristics peaks of Cefixime Trihydrate are obtained at 3564.72 cm^{-1} , 3293.56 cm^{-1} .

Figure 5: Spectra of Cefixime Trihydrate with sod.CMC, HPMC, EC, MCC

The characteristics peaks of Cefixime Trihydrate are obtained at 3564.72 cm^{-1} , 3293.56 cm^{-1} .

Figure 6: Drug release profile of Cefixime Trihydrate matrix tablets

Formulation F5 shows drug release up to 12 h, it is the optimized formulation

Figure 7: Comparative Zero order plots for formulations F1 – F5

Figure 8: Comparative Zero order plots for formulations F6 – F9

Figure 9: Comparative first order plots for formulations F1 – F5

Figure 10: Comparative first order plots for formulations F6 – F9

Figure 11: Comparative Higuchi's plots for formulations F1-F5

Figure 12: Comparative Higuchi's plots for formulations F6-F9

Figure 13: Comparative Peppas's plots for formulations F1-F5

Figure 14: Comparative Peppas's plots for formulations F6-F9

ABBREVIATIONS

HPMC -Hydroxy propyl methyl cellulose
 Sod CMC- Sodium corboxy methyl cellulose
 EC - Ethyl cellulose
 MCC-Micro crystalline cellulose
 FTIR- Fourier Transform Infrared Spectroscopy

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