IJPSR (2014), Vol. 5, Issue 4 **(Research Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 31 October, 2013; received in revised form, 14 January, 2014; accepted, 11 March, 2014; published 01 April, 2014

FORMULATION AND *IN-VITRO* EVALUATION OF SUSTAINED RELEASE MATRIX TABLET OF DICYCLOMINE HYDROCHLORIDE BY USING HYDROPHILIC POLYMERS

Kiran Joshi *, Shashikant Dhole and Anjali Doltode

Department of Pharmaceutics, Modern College of Pharmacy (for Ladies), Moshi, Pune, Maharashtra, India

Keywords:

Matrix tablets, Dicyclomine hydrochloride, Guar gum, Xanthan gum, Pectin

Correspondence to Author:

Kiran Joshi

Department of Pharmaceutics, Modern College of Pharmacy (for Ladies), Moshi, Pune, Maharashtra, India

E-mail: kiran23.joshi@gmail.com

ABSTRACT: The objective of the present study was to develop Sustained release matrix tablets of Dicyclomine hydrochloride to reduce the dosing frequency to twice daily thereby increasing patient compliance and therapeutic efficacy. Twelve batches of tablets were fabricated using hydrophilic polymer guar gum alone or in combination with xanthan gum and pectin. All the batches were formulated by wet granulation and evaluated for thickness, weight variation, hardness, drug content uniformity, swelling index and in - vitro drug release profile. The results obtained were satisfactory and complied with the Pharmacopoeial specifications. From the twelve batches, B9 formulation had better control over release rate and can increase patient compliance through twice daily dosing. In- vitro drug release for B9 formulation containing 1:3 drug: polymer (guar gum and pectin) ratio was found to be 18.21% at the end of 2nd hour and 81.26% at the end of 11th hour. The dissolution data was fitted into various models to determine the mechanism of drug release. Kinetics of drug release of the optimized batch showed that zero order model was best fit for release of Dicyclomine hydrochloride from prepared dosage form. The optimised formulations B9 were found to be stable upto three months of stability testing at 40^{o}C / 75% RH.

INTRODUCTION: Sustained release systems include any drug - delivery system that achieves slow release of drug over an extended period of time [1]. Possible therapeutic benefits of a properly designed SR dosage form include low cost, simple processing, improved efficacy, reduced adverse events, flexibility in terms of the range of release profiles attainable, increased convenience and patient compliance [2].

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.5(4).1331-38

Article can be accessed online on: www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.5(4).1331-38

The most commonly used method of modulating the drug release is to include it in a matrix system. Hydrophilic polymer matrix systems are widely used in oral sustained drug delivery because of their flexibility to obtain a desirable drug release profile, cost effectiveness, and broad regulatory acceptance [3].

Guar gum is a nonionic polysaccharide derived from the seeds of *Cyamopsis tetragonolobus*, family Leguminosae. It consists of linear chains of (1- 4)-b-D-mannopyranosyl units with a-D-galactopyranosyl units attached by (1- 6) linkages [4].

Many reports appear on the use of guar gum, as a hydrophilic matrix, for designing oral controlled release dosage forms [5, 6, 7].

Xanthan gum is a high molecular weight hydrophilic polymer, produced on commercial scale by the viscous fermentation of gram negative bacterium *Xanthomonas campesteris* [8]. Various groups of workers have used xanthan gum to prepare sustained-release matrix tablets [9, 10].

Pectin is a complex hydrophilic, heterogeneous poly-saccharide consisting mainly of esterified D-galacturonic acid residue and its methyl ester in α(1-4) chain. It is a natural polymer found in the cell walls in most of the higher plants [11]. It is has shown to be useful for the construction of drug delivery systems for specific drug delivery [12, 13].

Dicyclomine hydrochloride is an anticholinergic agent having direct smooth muscle relaxant action, and in addition to being a weak anticholinergic, it exerts antispasmodic action. Its plasma half-life is 4 - 6 hours [14]. It is commonly used for the treatment of irritable bowel syndrome. It is rapidly absorbed after oral administration with peak plasma concentration occurring in 60-90 minutes. Conventional therapy of Dicyclomine hydro-chloride requires multiple daily administrations (3-4 times daily) [15].

Therefore it was felt that inclusion into a sustained release dosage form may be beneficial in terms of increasing patient compliance through twice daily dosing, and thereby improving therapeutic outcomes.

Furthermore, sustained delivery of dicyclomine hydrochloride may decrease the incidence of side effects such as dry mouth, blurred vision, anorexia, nausea and tachycardia, since the initial peak plasma levels seen with immediate release product dosing would be replaced by a more gradual plasma concentration increase and ultimately a sustained blood level.

Hence, the present study has been undertaken to formulate and evaluate sustained release matrix tablets of Dicyclomine hydrochloride using natural polymer guar gum alone or in combination with xanthan gum and pectin as suitable hydrophilic matrix system in view to improve patient compliance and therapeutic action.

MATERIALS AND METHODS:

Materials: Dicyclomine hydrochloride was kindly gifted from Palam Pharma Pvt. Ltd. (Ahmedabad, India). Pectin was obtained as a gift sample from Krishna Pectins Pvt. Ltd. (Jalgaon, India). Guar gum, Xanthan gum and PVP K-30 were obtained from Research - lab fine Chem Industries (Mumbai, India). Lactose, Magnesium stearate and Talc were obtained from Loba chemie Pvt. Ltd. (Mumbai, India). All other chemicals used were of analytical grade.

Methods:

Drug - excipients interaction study: It was used to study the interactions between the drug and polymers. The drug and polymers must be compatible to produce a stable product. The samples of drug and physical mixture of drug and excipients were powdered and intimately mixed with dry powdered potassium bromide. The powdered mixture was analysed in a FT-IR Spectrophotometer. The IR spectrum of drug was compared with that of the physical mixture to check for any possible drug - excipients interaction [16].

Formulation of Sustained Release Matrix Tablets: Matrix tablets of Dicyclomine HCl were prepared by wet granulation technique. Lactose was used as diluent and the mixture of talc and magnesium stearate 2:1 ratio was used as lubricant. The composition of the formulations of tablets with different proportions of natural polysaccharides is listed in **Table 1**.

Dicyclomine HCl and all other ingredients were passed through sieve no. 60 separately and mixed homogeneously. The dry powder blend was granulated with PVP K-30 which was dissolved in isopropyl alcohol. The coherent mass was passed through standard sieve no. 22. The granules were dried at room temperature for 30 minutes. The dried granules were again passed through sieve no. 22 and were lubricated with a mixture of talc and magnesium stearate. Finally, the lubricated granules were compressed into tablets with an average weight of 200±15 mg using 8 mm concave punches in an eight station rotary tablet press (CIP Machineries Pvt. Ltd., India) to a hardness of 4-6 kg/cm^2.

TABLE 1: COMPOSITION OF DIFFERENT BATCHES OF MATRIX TABLET

Ingredients (mg)	Batch											
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
Drug: polymer	1:1	1:2	1: 3	1:1	1:2	1:3	1:1	1:2	1:3	1:1	1:2	1:3
Guar gum	40	80	120	20	40	60	20	40	60	20	40	60
Xanthan gum	-	-	-	20	40	60	-	-	-	10	20	30
Pectin	-	-	-	-	-	-	20	40	60	10	20	30
Lactose	104	64	24	104	64	24	104	64	24	104	64	24
PVP K-30 in IPA	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.
Magnesium stearate	2	2	2	2	2	2	2	2	2	2	2	2
Talc	4	4	4	4	4	4	4	4	4	4	4	4

Evaluation of Sustained Release Matrix Tablets:

Pre-compression parameters [17, 18]: Before compression, the granules were evaluated for their flow and compressibility characteristics.

Angle of Repose: The angle of repose of the granules was determined by the funnel method. The granules were allowed to flow through the funnel fixed to a stand at definite height. The angle of repose (θ) was then calculated by measuring the height (h) and radius (r) of the heap of granules formed using formula,

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

Granules with angle of repose upto 30^o show good flow of the granules.

% Compressibility or Carr's Index: The bulk and tap density of the granules were determined and Carr's index was calculated using formula;

Carr's Index =

$$\frac{\text{Tapped density - Bulk density}}{\text{Tapped density}} \times 100$$

Granules with compressibility index value upto 16 % show good flow property.

Post-compression parameters:

Evaluation of physical properties: The prepared matrix tablets were evaluated for thickness, weight variation, hardness and friability. The thickness of the tablets was determined by Vernier calliper. Five tablets from each batch were used and average values were calculated [19]. The weight variation was performed (n=20 tablets) using an electronic balance according to IP [20]. Hardness of the tablets (n=6) was tested using a Monsanto hardness tester [21].

Friability of the tablets (n=10) was determined in a Roche friabilator for 4 minutes at a speed of 25 rpm [20, 21].

Content Uniformity: At random, 20 tablets were weighed and powdered. A quantity of the powder equivalent to 100 mg was transferred into 100 ml volumetric flask containing 0.1 N HCl and sonicated for five minutes. Volume was adjusted to 100 ml with 0.1 N HCl and filtered through Whatman filter paper, diluted appropriately and the drug was estimated at λ_{max} of 421 nm using UV spectroscopy [22].

Swelling Index: Swelling index was determined by taking the initial weight of dried tablet (W_0). The tablet was immersed in 0.1 N HCl for 2 hours and in phosphate buffer pH 6.8 for the rest hours. The swollen tablets were withdrawn periodically after every 60 minutes from the medium and reweighed (W_t) after removal of excess surface water by light blotting with a filter paper. The swelling index was calculated using the formula [23];

$$SI = \frac{W_t - W_0}{W_0} \times 100$$

***In-vitro* drug release studies:** Dissolution studies were carried out in 900 ml of 0.1 N HCl for first 2 hours followed by simulated intestinal fluid pH 6.8 phosphate buffer for rest hours. The drug release studies were carried out using USP dissolution apparatus (apparatus I, 100 rpm, 37 $\pm 0.5^0$C). 5 ml of the sample was withdrawn at every hour for 12 hours and the same volume of fresh medium was replaced every time. Two samples each of 1ml were taken and mixed with 1 ml of methanol to ensure the solubility of finely suspended particles of Dicyclomine HCl. Afterwards samples were diluted with respected dissolution fluid to make up to 5 ml.

An aliquot (2 ml) was pipetted out in to a 10 ml volumetric flask containing methyl orange solution (2 ml). The final volume was adjusted to 5 ml with 0.1N hydrochloric acid. Chloroform (5 ml) was added and mixed well. The drug – dye ion pair complex was extracted in chloroform. The chloroform layer was separated out and dried over anhydrous sodium sulphate. The absorbance of the coloured solution was measured Spectrophotometrically at 421 nm against reagent blank [24, 25].

Drug release kinetics: For finding out the mechanism of drug release from matrix tablet, the dissolution data obtained from the above expressions were treated with the different release Kinetic equations like Zero order, First order, Higuchi, Hixson-Crowell and Korsemeyer-Peppas equation [26, 27].

Stability studies: The optimized formulation was subjected for 3 month stability studies according to ICH guidelines by exposing the tablets in suitable packing mode and placing them to a temperature of 40^0C and relative humidity of 75±5% RH in programmable environmental test chamber. At the end of every month, the tablets were analysed for any change in appearance, drug content and in – vitro release studies [28].

RESULTS AND DISCUSSION:

Drug - excipients interaction study: FT-IR studies revealed that Dicyclomine HCl showed characteristic peaks at 2932 cm^{-1} (C-H stretching), 2358 cm^{-1} (CO_2 stretching), 1718 cm^{-1} (C=O ester stretching) and 1447 cm^{-1} (C-H bending). No significant shifts of reduction in intensity of Dicyclomine HCl were observed in the physical mixture of drug and excipients as shown in **Fig. 1**. The results proved that there was no drug - excipients interaction.

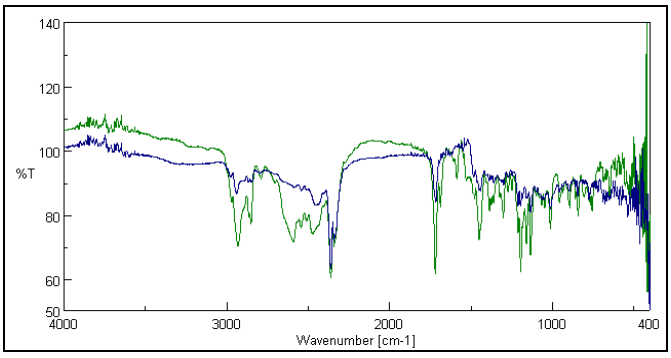

FIG. 1: IR SPECTRA OF DRUG AND PHYSICAL MIXTURE OF DRUG-EXCIPIENTS

Evaluation of Sustained Release Matrix Tablets:

Pre-compression parameters: The values of angle of repose and Carr's index were determined and results are shown in **Table 2**. The values of angle of repose and Carr's index were found to be in the range from 21^o ± 0.26 to 24.99^o ± 1.51 and 12.58% to 16.43% respectively. All the formulations showed good flow property.

TABLE 2: RESULTS OF GRANULAR PROPERTIES

Formulation	Angle of repose* (^{o})	Carr's index (%)
B1	21 ± 0.86	16.17
B2	21 ± 0.26	12.58
B3	22.20 ± 1.67	16.21
B4	22.73 ± 1.43	13.51
B5	23.62 ± 3.12	14.86
B6	24.43 ± 2.92	15.06
B7	24.99 ± 1.51	13.24
B8	22.75 ± 2.48	14.56
B9	24.24 ± 1.5	15.94
B10	23.8 ± 2.63	16.43
B11	23.95 ± 1.77	13.51
B12	24.7 ± 3.06	13.01

*The values represent mean ±SD, n=3

Post-compression parameters: The physical properties of different batches of matrix tablet are given in **Table 3**. The mean thickness of all the formulations was almost uniform and the values ranged from 3.23 ± 0.01 mm to 3.37 ± 0.03 mm. All the formulations passed the test for uniformity of weight as the percentage weight variations for all formulations were within the Pharmacopoeial limits of ±7.5% of the weight. The mean values of hardness ranged from 4.9 ± 0.2 - 5.9 ± 0.2 kg/cm^2 ensuring good handling characteristics of all the batches. The values of % friability were found to be below 1% indicating that the formulations are having good compactness and mechanical strength. Good uniformity in drug content was found among different batches of the tablets and the percent of drug content was more than 95%.

Swelling studies showed that most of the tablets swelled within the first two hours and erosion began to take place. However, batches B3, B6 and B12 showed good swelling behaviour even up to 10 hours with batch B6 showing the greatest water absorption. As the concentration of polymers increase, the swelling index of the tablets also increases.

TABLE 3: PHYSICAL PROPERTIES OF COMPRESSED TABLET

Formulation	Thickness[1] (mm)	Average weight (mg)	Hardness[2] (kg/cm^2)	Friability (%)	Content uniformity (%)
B1	3.37 ± 0.03	201.6	4.9 ± 0.1	0.75	98.9
B2	3.33 ± 0.05	203.1	5.2 ± 0.2	0.6	97.5
B3	3.28 ± 0.02	201.7	5.3 ± 0.1	0.45	99.4
B4	3.27 ± 0.01	199.2	5.4 ± 0.3	0.65	100.6
B5	3.26 ± 0.03	199.1	5.8 ± 0.3	0.45	101.4
B6	3.23 ± 0.01	199.4	5.9 ± 0.2	0.3	96.4
B7	3.25 ± 0.04	203.1	5.2 ± 0.1	0.6	98.6
B8	3.27 ± 0.05	200.9	5.1 ± 0.1	0.65	99.8
B9	3.34 ± 0.02	199.1	4.9 ± 0.2	0.75	98.3
B10	3.27 ± 0.01	204.2	5.1 ± 0.2	0.65	99.5
B11	3.28 ± 0.03	200.1	5.3 ± 0.2	0.55	97.5
B12	3.31 ± 0.02	199.6	5.2 ± 0.3	0.55	100.6

[1]The values represent mean ±SD, n=5; [2]The values represent mean ±SD, n=6

Batches B1, B4, B7 and B10 failed to swell due to the low concentration of polymers. In Batch B2 and B3 containing only guar gum, there was initial slow swelling followed by high swelling after 4-5 hours. Batches B5, B8 and B11 containing intermediate concentration of polymers swelled upto 3 hours followed by erosion. In Batch B9 containing combination of guar gum and pectin, pectin swelled initially due to its high swelling property but after 4-5 hours, erosion occurs. **Fig. 2** shows the swelling index of the batches of tablets compressed.

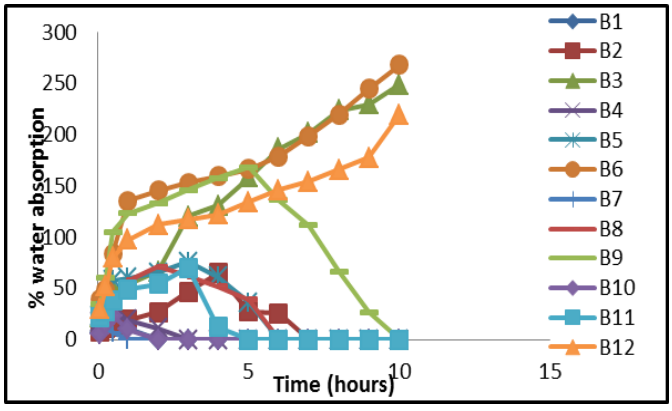

FIG. 2: SWELLING INDEX OF THE BATCHES OF TABLETS COMPRESSED

The data obtained from in-vitro release studies for formulation batches B1 to B6 and B7 to B12 are shown in the **Fig. 3 & 4** respectively. In Batches B1, B4, B7 and B10 having low concentrations of polymers, a very rapid release of drug is observed. In batch B2, an initial burst release may be due to uncontrolled rate of hydration and an initial slow gelling of guar gum but after 4-5 hours, release rate become slow due to high swelling of guar gum [29]. Batch B3 contained 60% guar gum and sustained the drug release for more than 12 hours.

In batch B5 and B6, 85.47% and 34.82% of drug was released at the end of 8 and 11 hours respectively. As the amount of Xanthan gum in the matrix is increased a greater retardation of drug is observed. This may be due to the greater degree of swelling of Xanthan gum [30]. In batch B8 and B9, 80.24% and 81.26% of drug was released at the end of 7 and 11 hours respectively.

In batch B9, pectin was used in combination with guar gum that might control the burst effect by promoting gelation both in radial and axial expansion and after 4-5 hours, pectin maintained the release rate by acting as an eroding material and controlled the drug release up to 11hours [31]. In batch B11 and B12, 82.48% and 41.09% of drug was released at the end of 9 and 11 hours respectively.

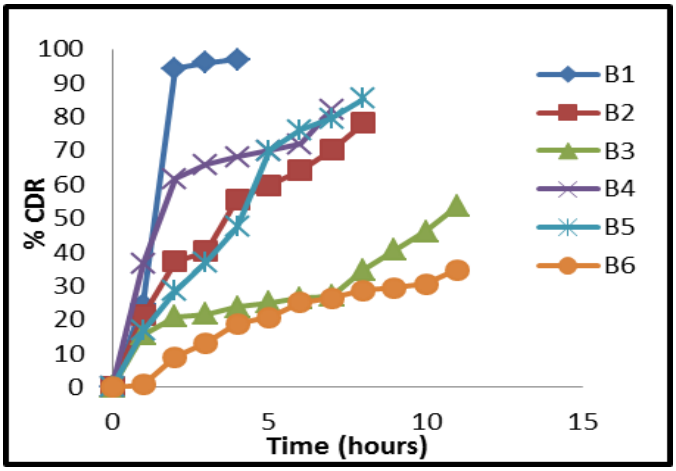

FIG. 3: DRUG RELEASE PROFILE OF BATCH B1-B6

The optimised batch selected was B9 as the initial drug release was less and it showed drug release of 81.26% at the end of 11hours.

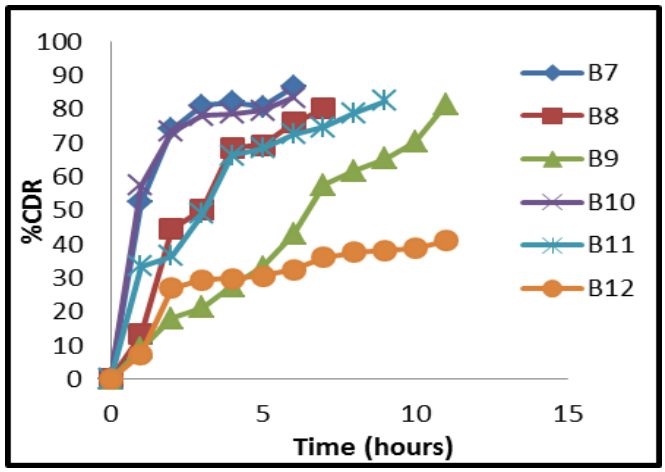

FIG. 4: DRUG RELEASE PROFILE OF BATCH B7-B12

The curve fitting result of the release rate profiles of the formulation gave an idea on the release rate and mechanism of drug release. The results of kinetic treatment applied to dissolution profiles of tablet of each batch were shown in **Table 4**. It was found that Batches B1, B4, B7, B10 followed Korsemeyer Peppas model; Batches B2, B8, B11 followed First order model; Batches B6, B12 followed Higuchi model and Batches B3, B9 followed Zero order model. Fitting of the release data to Korsemeyer Peppas model, it was reported that the diffusion co-efficient for Batches B4, B7, B10 was found to be < 4.5 indicating Fickian diffusion mechanism; for Batches B2, B3, B5, B8, B9, B11, B12 it was found to be between 0.45-0.89 indicating anomalous transport mechanism; for Batches B1, B6 it was found to be >0.89 indicating supercase II transport mechanism. The optimised Batch B9 followed zero order model followed by Korsemeyer Peppas model.

TABLE 4: DISSOLUTION DATA TREATMENTS OF TABLETS OF BATCH B1-B12

Batch	Zero order	First order	Higuchi	Hixson-Crowell	Korsemeyer Peppas		Best fit model
	R^2	R^2	R^2	R^2	R^2	n	
B1	0.6298	0.7602	0.7188	0.6994	0.7903	1.009	K.-Peppas
B2	0.9249	0.9755	0.9693	0.9695	0.9231	0.815	First order
B3	0.9112	0.8748	0.8509	0.8886	0.8902	0.539	Zero order
B4	0.7751	0.8597	0.8466	0.8417	0.8662	0.353	K.-Peppas
B5	0.962	0.9701	0.9673	0.9739	0.9839	0.826	K.- Peppas
B6	0.9261	0.9507	0.9806	0.9432	0.8443	1.316	Higuchi
B7	0.6939	0.7961	0.7903	0.7644	0.8516	0.255	K.- Peppas
B8	0.8664	0.9614	0.9352	0.9379	0.8911	0.865	First order
B9	0.9831	0.9429	0.9571	0.9669	0.9694	0.842	Zero order
B10	0.7428	0.8336	0.8323	0.8046	0.8882	0.190	K.- Peppas
B11	0.9062	0.9667	0.9483	0.9512	0.9429	0.454	First order
B12	0.7316	0.7929	0.8225	0.773	0.763	0.555	Higuchi

A stability study was carried out at 40°C and 75% RH for three months on the optimized batch B9. The percentage of drug content before and after storage was found to be similar (**Table 5**).

The change in the drug release pattern i.e. dissolution profile was not significantly different from that of three months before (**Fig. 5**).

TABLE 5: DRUG CONTENT OF OPTIMIZED BATCH B9 FOR STABILITY STUDY

Sr. No.	Month	Drug content (%)
1.	0	98.86
2.	1	97.95
3.	2	97.26
4.	3	96.89

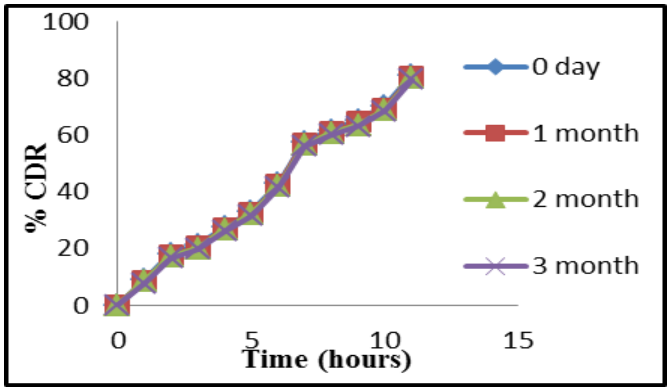

FIG. 5: DRUG RELEASE PROFILE OF OPTIMISED BATCH B9 FOR STABILITY STUDY

CONCLUSION: It can be concluded that Dicyclomine HCl can be successfully incorporated into a Sustained Release Matrix Tablet using natural polymers and this can be used for patients suffering from Irritable Bowel Syndrome with improved convenience and compliance.

The optimized formulation B9 showed cumulative % release of 81.26% at the end of 11 hours. This formulation has better control over release rate and can increase patient compliance through twice daily dosing. The formulations B3, B6 and B12 showed high retarding capacity than formulation B9.

The optimized batch exhibited zero order kinetics and the release profile was diffusion followed by erosion. Stability studies showed that there was no significant change in drug content and *in - vitro* drug release of optimised formulation (B9). Further, in- vivo investigations are required to correlate with in – vitro dissolution studies for the development of optimum oral sustained release matrix tablets of Dicyclomine HCl.

ACKNOWLEDGEMENT: The authors are thankful to Palam Pharma Pvt. Ltd. and Krishna Pectins Pvt. Ltd. for providing gift samples of drug and polymer. The authors acknowledge the facilities provided at Modern College of Pharmacy, Moshi, Pune in carrying out the research work.

REFERENCES:

1. Gennaro AR: Remington, The Science & Practice of Pharmacy. Mack Publishing Company, Edition 19, Vol. II, 1995: 1662.
2. Wadher JK, Kakde BR and Umekar JM: Formulation of Sustained Release Metformin Hydrochloride Matrix Tablets: Influence of Hydrophilic Polymers on the Release Rate and *In Vitro* Evaluation. Int. J. Res. Control. Release 2011; 1:9-16.
3. Tiwari SB, Murthy SK, Pai MR, Mehta PR and Chowdary PB: Controlled release formulation of tramadol hydrochloride using hydrophilic and hydrophobic matrix system. AAPS Pharm Sci Tech 2003; 4(3): E31.
4. Jain V and Singh R: Dicyclomine-loaded Eudragit®-based Microsponge with Potential for Colonic Delivery: Preparation and Characterization. Trop J Pharm Res 2010; 9 (1): 67-72.
5. McEvoy GK: Dicyclomine hydrochloride. Bethesda, MD: American Society of Health-System Pharmacists 2004; 1212-1213.
6. Rowe RC, Sheskey PJ and Weller PJ: Hand Book of Pharmaceutical Excipients, London: Pharmaceutical Press and American Pharmaceutical Association, Edition 4, 2003: 271-273.
7. Khullar P, Khar RK and Agarwal SP: Evaluation of guar gum in the preparation of sustained-release matrix tablets. Drug Dev Ind Pharm 1998; 24: 1095-1109.
8. Nakano M, Ogata A: Examination of natural gums as matrices for sustained release of theophyline. Chem. Pharm. Bull. 1984; 32: 782-785.
9. Mishra AN, Baweja JM: Modified guar gum as hydrophilic matrix for controlled release tablets. Indian Drugs 1997; 34: 216-223.
10. Yeole PG, Babla IB, Nakhat PD: Design and Evaluation of Xanthan gum based Sustained release matrix tablet of Diclofenac sodium. Indian J.Pharm.Sci. 2006; 68(2): 185-189
11. Dhopeshwarkar V, Zatz JL: Evaluation of xanthan gum in the preparation of sustained release matrix tablets. Drug Dev Ind Pharm 1993; 19: 999-1017.
12. Talukdar MM and Kinget R: Comparative study on xanthan gum and hydroxypropyl methyl cellulose as matrices for controlled-release drug delivery: II drug diffusion in hydrated matrices. Int J Pharm 1997; 151(1): 99-107.
13. Beneke CE, Viljoen AM and Hamman JH: Polymeric Plant-derived Excipients in Drug Delivery. Molecules 2009; 14: 2602-2620.
14. Linshu L, Marshall L and Fishman B: Pectin in controlled drug delivery – a review. J. Control Release 2007; 14: 15-24.
15. Sungthongjeen S, Pitaksuteepong T, Somsiri A and Sriamornsak P: Studies on pectins as potential hydrogel matrices for controlled release drug delivery. Drug Dev Ind Pharm 1999; 25(12): 1271-1276.
16. Sharma YR: Elementary Organic Spectroscopy Principles and Chemical applications. S, Chand and Co., New Delhi, 2005: 65-133.
17. Rockville, MD: United State Pharmacopoeia/National Formulary. United States Pharmacopoeial Convention, 29th Edition 2006.
18. Aulton ME: Pharmaceutics: The science of dosage form design. Churchill Livingstone, London, Edition 2, 2002: 133-134.
19. Lachman L, Lieberman HA and Kanig JL: The theory and practice of industrial pharmacy. Varghese publishing house, Bombay, Edition 3, 1987: 296.
20. Indian Pharmacopoeia, Controller of Publication, Govt. of India, Ministry of Health and Family Welfare, New Delhi, Vol. I, 2007: 182-183.
21. Odeku OA: Assessment of *Albizia zygia* gum as binding agent in tablet formulations. Acta Pharm. 2005; 55: 263-276.
22. Bolton S, Bon C: Pharmaceutical statistics: practical and clinical applications. Marcel Dekker, Inc., New York, 4th Edition, Revised and Expanded, Vol. 135, 2004: 408
23. Moin A and Shivakumar HG: Formulation of Sustained-Release Diltiazem Matrix Tablets Using Hydrophilic Gum Blends. Trop. J. Pharm. Res. 2010; 9: 283-291.
24. Muhammad AM, Zafar I, Steven HN: Guar Gum, Xanthan Gum and HPMC can define release mechanisms and sustain release of Propranolol hydrochloride. AAPS Pharm. Sci. Tech. 2011; 12: 77-87.
25. Verma S, Singh SK, Mishra DN, Gupta A and Sharma R: Formulation and Evaluation of Microbially- triggered tablets of Valdecoxib. Int. J. Drug Delivery Tech. 2009; 1: 6-11.

26. Costa P and Lobo MS: Modelling and comparison of dissolution profiles. Eur. J. Pharm. Sci. 2001; 13: 123-133.
27. Ritger PL, Peppas NA: A simple equation for description of solute release II. Fickian and anomalous release from swellable devices. J. Control Release 1987; 5: 37-42.
28. Mathews BR: Regulatory aspects of stability testing in Europe. Drug Dev Ind Pharm.1999; 25: 831-856.
29. Al-Saidan SM, Krishnaiah YSR, Patro SS and Satyanaryana V: *In vitro* and *in vivo* evaluation of guar gum matrix tablets for oral controlled release of water-soluble diltiazem hydrochloride. AAPS Pharm Sci Tech. 2005; 6(1): E14–21.
30. Shaikh A, Shaikh P, Pawar Y, Kumbhar S and Katedeshmukh R: Effect of gums and excipients on drug release of Ambroxol HCl sustained release matrices. J. Current Pharm. Res. 2011; 6: 11-15.
31. Gupta K, Singhvi I, Kale V, Avari JG and Agrawal N: A new binary polymeric matrix system for sustained release drug delivery of highly soluble drug: Diltiazem hydrochloride. Int. J. Drug Dev. Res. 2011; 3:162-170.

How to cite this article:
Joshi K, Dhole S and Doltode A: Formulation and *in-vitro* evaluation of Sustained Release Matrix Tablet of Dicyclomine hydrochloride by using Hydrophilic polymers. *Int J Pharm Sci Res* 2014; 5(4): 1331-38.doi: 10.13040/IJPSR.0975-8232.5(4).1331-38