RESEARCH ARTICLE

Formulation and evaluation of floating tablets of niacin for sustained release

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Niacin or nicotinic acid (NA) is used in the treatment of hyperlipidemia. NA immediate release formulation shows undesirable effects like flushing of the face and neck parts. In the present study, NA floating sustained release dosage form was developed to prolong the drug release, to retain the drug delivery system above the site of absorption for the desired period of time, and to reduce the drug release rate compared to conventional formulations in order to minimize the side effects. The preformulation parameters such as flow properties and drug-excipient compatibility studies were performed. The drug excipient compatibility studies were performed using the FTIR study and the results showed that all the polymers used in the study are compatible with the pure drug. The floating sustained release tablets of niacin were prepared by the wet granulation method and the granules were evaluated for various micromeritic properties like bulk density, tapped density, Carr's Index, Hausner's ratio, and angle of repose. The tablets were evaluated for post-compressional parameters like average weight, thickness, hardness, friability, swelling index, floating lag time and total floating time, and *in vitro* drug release studies. All the formulations showed total floating time >20 hr. The concentration of the effervescent agent and the concentration and type of polymer showed an effect on the floating behavior and drug release. The formulation containing 13% sodium bicarbonate, HPMC (33%) and Eudragit RS PO (4%) showed required drug release up to 20 hr.

Key words: *Nicotinic acid, floating drug delivery system, effervescent substance, polymer, floating time and sustained release*

INTRODUCTION

Floating drug delivery system (FDDS) is one of the oral controlled drug delivery systems, in which the dosage forms retains in the stomach for a prolonged period of time in order to improve bioavailability. FDDS is suitable for drugs having an absorption window either in the stomach or the upper small intestine, drugs acting locally in the stomach and for drugs that are poorly soluble or unstable in the intestinal fluid.[1] Generally, the density of these dosage forms is less than the density of gastric fluids (<1) to enables it to float in the stomach. FDDS are classified as effervescent systems and non-effervescent systems. The effervescent systems consist of an effervescent mixture like sodium bicarbonate and citric acid or tartaric acid or stearic acid along with a swellable polymer. This dosage form when comes in contact with the gastric fluid (pH 1.2–1.4) releases CO_2 that decreases the density of the tablet and causes the floating of the tablet.[2] In the present study, effervescent FDDS was developed using sodium bicarbonate as effervescent substance that maintains buoyancy of the tablet. The floating tablets of niacin were prepared with combination of different polymers. In this HPMC K100M was used as a primary polymer for all the formulations.

Niacin or nicotinic acid (NA) in low concentrations is used to treat B_3 vitamin deficiency and in higher concentrations used in the treatment of hyperlipidemia.[3] It is chemically Pyridine-3-carboxylic acid. It is a sparingly water-soluble drug. Its absorption takes place mainly in the stomach and in the upper part of the intestine.[4] Oral bioavailability of niacin is approximately 25–30% though it is rapidly absorbed from the gastrointestinal tract after oral administration.[5] Niacin when administered as conventional formulations shows *niacin or NA-flush* and limits the use of immediate release (IR) niacin. It has a short half life of 25–40 min and hence a sustained

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release (SR) drug delivery system had been developed in order to minimize its side effects and to prolong its release. The pKa of niacin is 4.8.[6,7] So therapeutically its absorption is dependent on pH (in the stomach). Hence, FDDS of niacin was developed in order to improve its oral bioavailability.

Many studies had been investigated to decrease the side effects and to improve the bioavailability of NA.[4,8,9] In the present study, a floating SR formulation of niacin was developed with various polymers to study their influence on floating behavior and the release rate of the drug and the results are reported here.

MATERIALS AND METHODS

Materials used in the study

NA, HPMC K100M, ethyl cellulose, eudragit RS 100, eudragit RL PO, eudragit RS PO, povidone K90, sodium alginate, Sodium CMC, hydroxypropylcellulose, sodium bicarbonate, aerosol and talc. All the materials were obtained from DR Reddy's Laboratories Ltd, Hyderabad.

Preformulation studies

The preformulation studies like flow properties and drug-excipient compatibility studies were performed for the pure drug and lubricated granules.

Flow properties

Bulk density and tapped density (g/ml)

The previously weighed pure drug or granules (W) was collected into a graduated measuring cylinder and the initial (or bulk) volume (V_B) was noted. It was placed in the tapped density tester USP and subjected to constant tapping at a rate of 200 drops/min until the difference between the initial and final volumes should be less than 2%. It was recorded as the final (tapped) volume (V_T) and various flow properties were calculated with the following formulae.[10]

$$\text{Bulk density, } \rho B = \frac{W}{VB} \quad (1)$$

$$\text{Tapped density, } \rho T = \frac{W}{VT} \quad (2)$$

$$\text{Carr's Index or Comressibility Index (C1)} = 1 - \frac{\rho B}{\rho T} \times 100 \quad (3)$$

$$\text{Hausner's Ratio} = \frac{\rho T}{\rho B} \quad (4)$$

Angle of repose (θ)

It was determined by using a funnel whose tip was fixed at a constant height (*H*) of 2.5 cm from the horizontal surface. The granules and the powder were passed separately through the funnel until the tip of the conical pile touches the tip of the funnel. The radius of the base of the conical pile is measured as R (cm). It is determined with the formula.

$$\text{Angle of repose, } (\theta) = \text{Tan}^{-1} \text{ (height /radius)} \quad (5)$$

Drug-excipient compatibility studies

Drug-excipient compatibility studies were performed for physical mixtures of NA with various excipients in different ratios such as 1:5 (drug: binder/polymer), 1:0.5 (drug: lubricant/glidant), 1:10 (drug: filler/diluents). They were placed in closed glass vials held at 40°C/75% RH. These samples were withdrawn at the end of 4th week and subjected to FTIR studies by employing KBr pellet method. The pellets were placed inside the pellet holder and then scanned over a range of 400–4000 cm^{-1} for five times. The threshold value was kept at 0.75 to avoid formation of extra peaks of noise. The peaks of physical mixtures were then correlated with the peaks of pure drug.[11]

Preparation of floating sustained release NA tablets

The NA floating SR tablets were prepared by the wet granulation method. The composition of tablets is given in Table 1. The drug and polymer which were previously passed through 40 mesh were mixed thoroughly in a polybag for 20 min. The blend was moistened with granulating fluid i.e., water and IPA (1:9 parts). The wet mass was passed through 24 mesh and then dried in a tray dryer at 50°C for about 50 min until the % LOD becomes less than 2%. The dried granules were passed through 30 mesh and mixed with sodium bicarbonate in a polybag for 10 min. To this talc (previously passed through 60 mesh) was added and mixed well for 10 min. The flow properties of the lubricated granules were evaluated. The lubricated granules were compressed by 16 station tablet compression machine (CADMACH) with 13.1 mm round concave punches.

Evaluation of NA tablets

The post compressional parameters like hardness, thickness, % friability, *in vitro* buoyancy study, swelling index, and drug content were determined for all the prepared tablets. The *in vitro* drug release studies were conducted for all formulations.

Weight variation

Twenty tablets were collected randomly and the average weight and individual weight was calculated. The % weight variation was calculated with the following formula.[4]

$$\%\,\text{Weight variation} = \frac{\text{Average weight} - \text{individual weight}}{\text{individual weight} \times 100} \quad (6)$$

Thickness

The thickness of the ten tablets was measured in mm by using Vernier calipers.[10]

Hardness

The hardness of the ten tablets was measured by using Varian V K200 Tablet Hardness Tester and is given in the units of KP.[10]

% Friability

Ten tablets were carefully dedusted prior to testing and weighed accurately (Wo). The tablets were placed in the drum

Table 1: Composition of floating SR nicotinic acid tablets

Ingredients	Quantity per tablet (mg)										
	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11
Nicotinic acid	375.13	375.13	375.13	375.13	375.13	375.13	375.13	375.13	375.13	375.13	375.13
HPMC K 100 m	250	250	250	250	250	250	250	250	250	150	350
SBC	75	100	100	100	100	100	100	100	100	100	100
Aerosil	3	3	3	3	3	3	3	3	3	3	3
Eudragit RSPO	30	30	-	-	-	-	-	-	-	30	30
Eudragit RLPO	-	-	30	-	-	-	-	-	-	-	-
Eudragit RS100	-	-	-	30	-	-	-	-	-	-	-
NA CMC	-	-	-	-	30	-	-	-	-	-	-
Sodium alginate	-	-	-	-	-	30	-	-	-	-	-
HPC KLUCEL Hf	-	-	-	-	-	-	30	-	-	-	-
Pvpk 90	-	-	-	-	-	-	-	30	-	-	-
Ethyl cellulose	-	-	-	-	-	-	-	-	30	-	-
Talc	3	3	3	3	3	3	3	3	3	3	3
IPA	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s
Purified water	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s	q.s
Total weight	736.13	761.13	761.13	761.13	761.13	761.13	761.13	761.13	761.13	661.13	861.13

of Electrolab Friabilator (USP) EF-2. The drum was rotated for 100 times at a speed of 25 rpm. The tablets were collected, re-dedusted and accurately weighed (W1). It is calculated form the following formula;[10]

$$\% \text{ Friability} = 1 - \frac{W1}{W0} \times 100 \quad (7)$$

Floating lag time (FLT)

The tablet ware placed in a beaker containing 250 ml of 0.1N HCl and the time (sec) required to float the tablet was observed and recorded as FLT.[12]

Total floating time (TFT)

The time (hr) up to which the tablet remains buoyant was noted and recorded as TFT.[12]

Determination of swelling index

The previously weighed (W1) tablet was placed in USP apparatus type-I which was immersed in a bowel containing 900 ml of 0.1N HCl and maintained at 37 ± 0.2°C. The tablets were removed from the basket at regular intervals of time (up to 8 h with 1 h interval) and placed on a blotting paper to remove the excess medium. The tablet was reweighed (W2). The studies were repeated for all formulations in triplicate. The swelling index was calculated as follows:[13]

$$\text{Swelling Index} = W2 - W1/W1 \times 100 \quad (8)$$

Determination of drug content

10 tablets were weighed and crushed in a motor with pestle. The crushed powder equivalent to 100 mg of NA was weighed accurately and transferred to a clean, dried 100 ml volumetric flask. 50 ml of 0.1N HCl was added and shaken vigorously for about 10 min and sonicated for 4 h. The final volume was made up to 100 ml using 0.1N HCl and agitated for 5 min. A portion of it was centrifuged at 3000 rpm for 10 min. The centrifuged sample was filtered through 0.45 μm whatmann filter paper. A 2 ml of the filtered sample was pipetted out and transferred to a 100 ml volumetric flask and the volume was made up to 100 ml with 0.1N HCl and the flask was shaken for 5 min. The sample was then analyzed for the drug content at 261 nm using a UV spectrophotometer.

In vitro drug release studies

In vitro drug release studies were performed for all the formulated tablets. The method and equipment used for the study were previously validated. The tablets were placed in sinkers and were dropped into six bowls of dissolution apparatus (USP Type-II). Previously degassed 900 ml of 0.1N HCl was employed as dissolution media. The paddle speed was set at 100 rpm and temperature was maintained at 37±0.5°C. The sampling volume was 10 ml and the same was replenished with fresh dissolution medium. The samples were collected at 1, 3, 6, 9, 12, and 20 hr. The samples were collected as pooled samples and were analyzed at 261 nm using a UV spectrometer.[14]

Accelerated stability testing

The accelerated stability studies were conducted for the optimized formulation of atorvastatin calcium tablets at 40°C/75% RH for a period of 4 weeks and the withdrawn samples were evaluated for physical properties and *in vitro* drug release studies.[15]

RESULTS AND DISCUSSION

NA (Vitamin B_3) is used in higher concentrations to treat hyperlipidemia. The IR formulation of NA shows flushing of the face and neck parts and limits its use. Many approaches including SR dosage forms have been developed to reduce

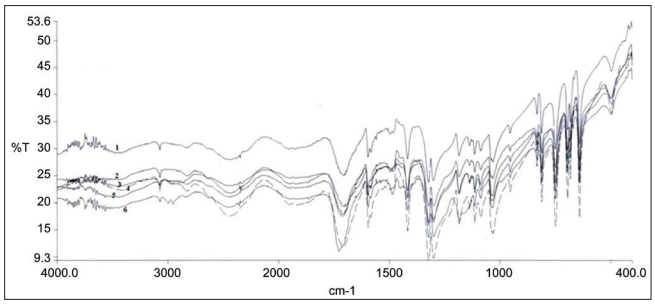

Figure 1: FTIR peaks of NA with different polymers. 1-Pure drug; 2-NA+Eudragit RS PO; 3- NA+HPMC; 4- NA+PVPK90; 5-NA+Eudragit RS 100; 6-NA+Eudragit RLPO

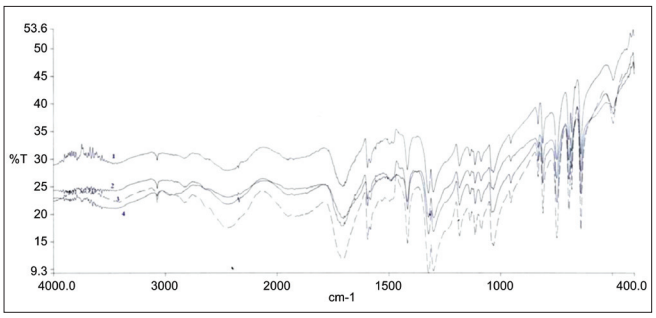

Figure 2: FTIR peaks of pure drug NA with different polymers. 1-Pure drug NA; 2-NA+sodium CMC; 3-NA+HPC; 4-NA+sodium alginate

the side effects of NA. In the present study, NA-floating SR tablets were prepared to achieve sustained release and to improve its oral bioavailability as it is majorly absorbed from stomach and upper small intestine.

Preformulation studies of NA were performed as a preliminary study to know the drug properties. The pure drug showed good flow properties [Table 2] as it is evidenced with the values of Carr's index (15.63) and angle of repose (28.52). The FTIR data was represented in Figures 1 and 2. It was observed that all the peaks of physical mixtures were superimposible with the peaks of pure drug and showed correlation coefficient greater than 0.9. Thus the FTIR studies confirmed that there were no drug- excipient interactions. NA as such can be compressed to formulate the tablets because of its flow properties. However, NA floating tablets were prepared by wet granulation method to increase the porosity of the granules that aids in floating of the tablet.

The preliminary studies are carried out by incorporating HPMC in different concentrations ranging from 20% to 40% w/w. The drug release rate was dependent on the concentration the polymer is employed. The formulation containing 32.85% w/w HPMC offered the slow release and thereafter the release was not much influenced by the polymer concentration. So to achieve the desired drug release rate and to study their influence on release rate of drug, various polymers were incorporated in combination with HPMC K100. The criteria for the selection of the polymer is based on the reported released retardant activity and exhibiting compatibility with

Table 2: Flow properties of pure drug of nicotinic acid

Parameter	Observation
Polymorphic state	Crystalline
Bulk density (g/ml)	0.707
Tapped density (g/ml)	0.838
Carr's index (%)	15.63
Hausner's ratio	1.185
Angle of repose (Θ)	28.52
Flow properties	Good flow

other components. As all the selected polymers were found to be compatible from IR spectral studies, the blend was subjected to wet granulation. The granules were evaluated for various flow properties like angle of repose, Carr's index, Hausner's ratio, and the results as are tabulated in Table 3. The Angle of repose values of all the formulations were in the range of 26°–29° indicating that the granules possess good flow properties. Post-compressional parameters like weight variation, thickness, and hardness were performed and they were found to comply with the compendia requirements [Table 4]. The hardness of all the tablets was found to be in range of 12–14 KP. The % friability of all the formulations was found to be less than 1% and hence these tablets can withstand any external stress that occurs during handling or transportation of tablets.

The *in vitro* buoyancy studies [Table 4] showed that the floating lag time was influenced by the concentration of $NaHCO_3$. The tablets formulated with 11% of $NaHCO_3$ showed a floating lag time more than 30 min. Hence, the tablets were formulated with higher concentration of $NaHCO_3$ (13%) and these tablets showed a floating lag time of 30 s. Further batches were formulated with 13% $NaHCO_3$. All the formulations showed a total floating time of more than 20 hr. The drug content [Table 4] of all the formulations was determined and they were in between 98–101% that meets the specifications (90–110%).

The swelling index [Table 5] of all the formulations was performed and all the tablets showed good swelling property and influenced by the other polymer. The effect of concentration of sodium carbonate on the swelling index of NA tablets was studied. The tablets that are formulated with 13% sodium bicarbonate showed more swelling index compared to tablets with 11% sodium bicarbonate (F1). This may be due to the increased reaction of sodium bicarbonate with the dissolution medium that increases the release of CO_2 which increases the number of pores there by increases the swelling index.

In vitro dissolution studies of all the formulations were performed using 0.1N HCL as dissolution media. The cumulative % drug release data of all the formulations is shown in Table 6. Different mathematical models were applied for describing the kinetics of the drug release process from the tablets. The rate of drug release from tablets was determined by finding the best fit of the dissolution data to

Table 3: Flow properties of lubricated granules of nicotinic acid

Formulation code	Angle of repose (θ)	Bulk density (g/ml)	Tapped density (g/ml)	Compressibility index (%)	Hausner's ratio	%LOD
F1	26.01	0.399	0.559	28.62	1.401	1.74
F2	26.34	0.336	0.502	28.09	1.494	1.89
F3	27.69	0.353	0.502	29.68	1.422	1.93
F4	28.34	0.335	0.470	28.72	1.404	1.83
F5	27.66	0.338	0.494	28.57	1.463	1.79
F6	27.69	0.350	0.485	27.83	1.387	1.87
F7	27.69	0.346	0.485	28.65	1.401	1.92
F8	27.34	0.351	0.491	28.71	1.403	1.90
F9	26.04	0.354	0.503	29.62	1.421	1.76
F10	27.34	0.323	0.469	29.13	1.452	1.96
F11	27.69	0.324	0.469	28.91	1.449	1.69

distinct models: zero order (eq. 1), first order (eq. 2), and mechanism of drug release from Higuchi (eq. 3) and Peppas (eq. 4) models.[14]

$Qt = k0\ t$ ---------- (eq. 1)

$Qt = Q_{\infty}\ (1-e^{-k_1 t})$ ---------- (eq. 2)

$Qt = kH\ t^{1/2}$ ---------- (eq. 3)

$Qt = kt^{n}$ or $\log Q = \log k + n \log t$ ---------- (eq. 4)

where Q_{∞} being the total amount of drug in the matrix, k_0 the zero-order kinetic constant, k1 the first-order kinetic constant, and k_H representing the Higuchi rate constant. The best fit model was found by using correlation coefficient values (*R*), using MS Excel.

The drug release from all the formulations followed first-order kinetics and controlled by anomalous non-Fickian diffusion as the exponential coefficient *n* value of all the formulations was in between 0.5 and 1.0. Hence, it was observed that diffusion is the rate limiting step in the release of drug through polymer matrices.[14] The release rate constant K (h^{-1}), T_{50}, and T_{90} values of all the formulation were calculated and shown in Table 7.

The rate of drug release from the formulation with 11% of sodium carbonate (F1) was relatively more compared to formulation with 13% of sodium bicarbonate (F2). This may be due to more swelling index of F2 tablets compared to F1 tablets. Hence, it was concluded that concentration of sodium bicarbonate influence the release rate.

The release of drug from the tablet was also influenced by the type of polymer used. The release rate was less in the formulation containing combination of HPMC and eudragit RS PO (F2) when compared to formulation containing combination of HPMC and eudragit RL PO (F3). This may be due to the low permeable nature and pH independent swelling of eudragit RS PO.[16]

The drug release from Eudragit RL PO is more, it may be due to its high permeable nature. The other polymers are checked for their drug retarding effect. The polymers like Na CMC, PVP K90, HPC, and sodium alginate retard the drug release in different rates based on their viscous nature and water swellable property. Ethyl cellulose polymer which is hydrophobic in nature controls the drug release by forming matrix with water swellable HPMC K100. Based on the drug release rates, the suitability of polymer for sustained release can be ranked as follows:

Eudragit RS PO > Eudragit RS 100> Ethyl cellulose> Na CMC> PVP K90> HPC > Sodium alginate> Eudragit RL PO.

Selection of optimized batch of NA tablets

The optimized batch of NA tablets was selected based on the values of similarity factor[17] (f_2) calculated with reference to drug release of patented niacin tablet (Niaspan).[18] Similarity factor is calculated between the factor % drug release of marketed tablet and NA formulations, by using the formula:

$$f_2 = 50 \times \log\left\{\left[1+\left(\frac{1}{n}\right)\sum_{t=1}^{n} w_t \left(R_t - T_t\right)^2\right]^{-0.5} \times 100\right\} \qquad (9)$$

where, R_t and T_t represent the percent drug dissolved at time t for reference and test, respectively, and *n* is the number of time points tested. The dissolution profile was considered satisfactory if f_2 value is more than 50 (nearing 100).

The formulation containing combination of HPMC and Eudragit RS PO (F2) showed a good similarity with the patented tablet with f_2 value of 65.16. To optimize the concentration of the HPMC, the formulations were further prepared with 23 % (F10) and 41% (F11) of HPMC and subjected to drug release studies. The swelling and cumulative % drug release of these formulations was shown in Figures 3 and 4, respectively. There was no increase in similarity factor values with these alterations and the similarity factor values

Table 4: Post compressional parameters of the formulated NA floating SR tablets

Formulation code	Average weight	Thickness (mm)	Hardness (KP)	% Friability	% Drug content	FLT (SEC)	TFT (HR)
F1	736.7 ± 0.500	6.14 ± 0.015	12.75 ± 0.105	0.163	98.58	1821	>20
F2	761.3 ± 0.527	6.28 ± 0.009	12.87 ± 0.138	0.092	101.61	26	>20
F3	761.4 ± 0.707	6.28 ± 0.010	12.77 ± 0.115	0.144	101.87	27	>20
F4	761.3 ± 0.881	6.29 ± 0.010	12.86 ± 0.091	0.145	98.22	30	>20
F5	761.5 ± 0.500	6.25 ± 0.014	12.86 ± 0.121	0.131	100.65	18	>20
F6	761.4 ± 0.527	6.29 ± 0.007	12.71 ± 0.147	0.197	100.91	28	>20
F7	761.2 ± 0.707	6.28 ± 0.019	12.87 ± 0.150	0.105	100.83	27	>20
F8	761.3 ± 0.527	6.28 ± 0.011	12.87 ± 0.076	0.183	98.65	30	>20
F9	761.4 ± 0.667	6.27 ± 0.030	12.8 ± 0.089	0.105	99.88	53	>20
F10	661.3 ± 0.632	5.64 ± 0.036	12.62 ± 0.179	0.136	99.59	21	>20
F11	861.6 ± 0.666	6.96 ± 0.019	12.81 ± 0.134	0.127	99.60	48	>20
F2*	761.2 ± 0.457	6.28 ± 0.0014	12.89 ± 0.125	0.085	100.57	29	>20

*Indicates stability hold sample at 45˚C/75% RH for a period of 4 weeks, FLT: Floating lag time, TFT: Total floating time

Table 5: Swelling index of NA tablets

Time (hours)	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F2*
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	85.72	96.0	83.5	82.7	105.7	114.2	71.1	110.2	68.9	83.9	97.4	94.2
2	92.96	113.7	106.1	108.1	128.0	160.4	100.5	152.7	102.6	111.6	120.4	111.3
3	149.2	153.5	147.6	148.4	155.5	187.4	149.2	181.3	129.5	122.0	178.9	151.8
4	160.8	165.3	164.7	173.7	178.6	197.0	153.5	199.9	138.4	148.4	189.0	162.3
5	171.9	188.6	184.3	188.5	193.3	216.1	164.5	209.9	150.3	176.1	192.2	183.4
6	194.3	190.2	190.3	189.7	200.1	226.7	184.2	222.5	171.5	180.4	211.6	186.5
7	201.2	203.1	202.0	202.6	209.9	239.8	191.4	237.1	177.5	200.3	218.3	201.3
S8	214.1	215.0	210.5	209.2	216.4	254.3	211.2	242.7	187.4	208.9	247.0	213.8

*Indicates stability hold sample at 45˚C/75% RH for a period of 4 weeks

Table 6: Cumulative % drug release profiles of NA tablets

Time (hours)	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F2*
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
1	21.5	17.1	24.0	21.4	22.0	22.1	23.3	20.8	20.4	26.3	21.9	18.00
3	39.0	36.4	44.9	39.0	40.6	39.9	41.6	36.8	39.4	42.1	39.3	34.10
6	57.6	54.7	69.1	57.7	58.7	61.2	60.1	53.6	60.0	58.6	58.0	50.19
9	71.7	65.2	88.2	71.6	71.9	77.5	79.8	68.1	75.8	77.5	71.8	68.28
12	83.5	77.4	96.4	82.2	83.1	91.3	88.8	86.6	82.0	88.1	80.8	84.37
20	97.9	99.6	100.7	99.6	99.0	101.2	100.5	101.9	99.1	98.1	99.6	107.46

*Indicates stability hold sample at 45˚C/75% RH for a period of 4 weeks

Table 7: Drug release kinetics of NA tablets

Formulation code	Correlation coefficient *r* value				Best fit model	Release rate constant (k) hr-1	Exponential coefficient value (*n*)	T50 (hours)	T90 (hours)
	Zero order	First order	Higuchi	Peppas					
F1	0.9360	0.9844	0.9966	0.9973	Peppas	0.1418	0.5194	4.88	16.23
F2	0.9300	0.9600	0.9979	0.9971	Higuchi	0.1181	0.5845	5.86	19.49
F3	0.8866	0.9910	0.9780	0.983	Peppas	0.2785	0.5103	2.48	8.26
F4	0.9397	0.9409	0.9981	0.9982	Peppas	0.1349	0.5228	5.13	17.06
F5	0.9355	0.9663	0.9974	0.9976	Peppas	0.1390	0.5098	4.98	16.55
F6	0.9256	0.9892	0.9915	0.9938	Peppas	0.1995	0.5331	3.47	11.54
F7	0.9218	0.9900	0.9900	0.9940	Peppas	0.1749	0.5094	3.96	13.16
F8	0.9538	0.9697	0.9959	0.9974	Peppas	0.1618	0.5448	4.28	14.23
F9	0.9310	0.9650	0.9950	0.9940	Higuchi	0.1350	0.5400	5.13	17.04
F10	0.9181	0.9931	0.9912	0.9941	Peppas	0.1661	0.4630	4.17	13.86
F11	0.9397	0.9400	0.9984	0.9984	Peppas	0.1276	0.5130	5.42	18.03
F2*	0.9720	0.9859	0.9918	0.9980	Peppas	0.1510	0.6166	4.59	15.2

*Indicates stability hold sample at 45˚C/75% RH for a period of 4 weeks

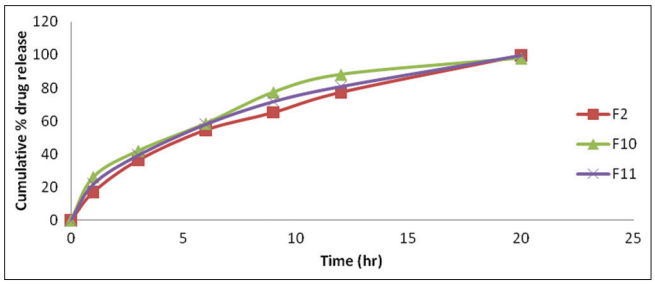

Figure 3: Cumulative % drug release profiles of F2, F10, and F11

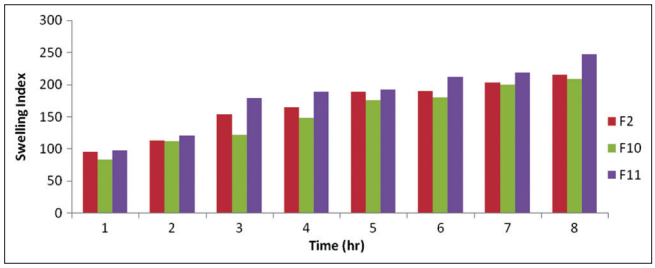

Figure 4: Comparison of swelling index of F2, F10, and F11

were found to be 47.06 and 54.47, respectively. Hence, the optimum concentration of HPMC was found to be 33% w/w. The % drug release of niacin from stability F2 sample showed good similarity with that of initial F2 sample and the *f*2 value was found to 66.53. Hence, the selected formulation was found to be stable.

CONCLUSION

In the present investigation, sustained-release floating tablets of niacin were developed in order to control the release of drug for a period of 20 hr. It was observed that the rate of drug release was controlled by the nature of the polymer and its concentration. The floating nature was controlled by the concentration of sodium bicarbonate. Thus, by changing the concentration of the effervescent substance and altering the polymer and its concentration, the desired floating nature and the required drug release rate can be attributed.

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