**Advance Research in Pharmaceuticals and Biologicals**

(A Peer Reviewed International Journal for Pharmaceutical and Allied Research)

ISSN 2250-0774 USA CODEN: ARPBGZ

# EFFECT OF POYMERIC RATIOS OF HPMC K15, SODIUM ALGINATE AND XANTHAN GUM ON THE SWELLING INDEX OF NIMODIPINE SUSTAINED RELEASE AND IT'S SIGNIFICANCE

***M. Jaimini and B. Khurana**
**Jaipur College of Pharmacy, Sitapura, Jaipur Rajasthan, India.**

**Received on 12/12/2013** **Revised on 19/12/2013** **Accepted on 24/12/2013**

**ABSTRACT:**
The present study focuses on studying the effect of swelling capacity of Nimodipine Sustained release tablets such that for all formulations it increases as increase the concentration of gum in each formulation. During the study it was observed that drug release decreases with increasing concentration of gum and swelling index. The reason attributed to this fact is formation of thick gel layer by matrices around tablets that delays diffusion and release drug. It was observed that swelling index of matrix tablets containing only one natural polymer was less this may attributed to the lower water uptake and less hydrophilicity. For all the ten formulations there was no occurrence of initial burst release, but the release was constant in a controlled manner for a prolong period of time up to 12hrs. The initial release of drug from these matrices occurs by the drug dissolution in the water penetrated into the matrix. The overall drug release from these matrices is governed by hydration, gel layer formation and drug diffusion into the gel layer and to the dissolution media. Polymer erosion also plays a major role in releasing drug from these matrices. . Swelling index of tablets prepared from NMP5 resulted as better swelling behavior with respect to concentration.

**Keywords:** Hydration, Polymer erosion, Swelling capacity, Diffusion.

***Corresponding Author:**
**Dr. Manish Jamini**
HOD,
Department of Pharmaceutics
Jaipur College of Pharmacy, Jaipur, India.
Email: bhawna.pharma89@gmail.com
Phone no: +91-9968634569

## INTRODUCTION

The swelling behaviour indicates the rate at which tablets absorb the water from dissolution media and swells. Swelling of matrix tablets increases with respect to time because weight gain by tablets was increased proportionally with rate hydration up to 4hrs and matrix appeared swollen almost from the beginning and a viscous gel mass was created after contact with water later on swelling were decreases due to dissolution of outermost gelled layer of tablets[1,2].

In order to overcome the drawbacks of conventional drug delivery systems, several technical advancements have led to the development of controlled drug delivery system that could revolutionize method of medication and provide a number of therapeutic benefits. Nimodipine is one such anti-hypertensive drug, where these problems are incurred.

Nimodipine is a 1,4-dihydropyridine calcium channel blocker. It acts primarily on vascular smooth muscle cells by stabilizing voltage-gated L-type calcium channels in their inactive conformation. By inhibiting the influx of calcium in smooth muscle cells, nimodipine prevents calcium-dependent smooth muscle contraction and subsequent vasoconstriction[3].

Oral controlled release drug delivery is a drug delivery system that provides the continuous oral delivery of drugs at predictable and reproducible kinetics for a predetermined period throughout the course of GI transit and also the system that target the delivery of a drug to a specific region within the GI tract for either a local or systemic action[4].

All the pharmaceutical products formulated for systemic delivery via the oral route of administration, irrespective of the mode of delivery (immediate,

sustained or controlled release) and the design of dosage form (either solid dispersion or liquid), must be developed within the intrinsic characteristics of GI physiology[5].

Therefore the scientific framework required for the successful development of oral drug delivery systems consists of basic understanding of:

1. **Development of a drug delivery system:** To develop a viable oral controlled release drug delivery system capable of delivering a drug at a therapeutically effective rate to a desirable site for duration required for optimal treatment[6].
2. **Modulation of gastrointestinal transit time:** To modulate the GI transit time so that the drug delivery system developed can be transported to a target site or to the vicinity of an absorption site and reside there for a prolonged period of time to maximize the delivery of a drug dose[7].
3. **Minimization of hepatic first pass elimination:** If the drug to be delivered is subjected to extensive hepatic first-pass elimination, preventive measures should be devised to either bypass or minimize the extent of hepatic metabolic effect[8].

**Effect of Release Limiting Factor on Drug Release**

The parameters such as partition coefficient diffusion path thickness and other systems play various rate determining roles in controlled release of the drugs from matrix systems.

1. **Polymer Hydration:** To determine the number of polymers and different polymeric combination it is important to study polymer hydration or swelling process. The important step include adsorption/absorption of water, rupture of polymer-polymer linking, formation of water-polymer linking , separation of polymeric chains, swelling and then dispersion[9].
2. **Drug Solubility:** Molecular size and water solubility of the drug are two important determinants in the release of drug from swelling and erosion. For drugs with good aqueous solubility the release occur by dissolution in filtrating membrane. For drugs with poor aqueous solubility release occur by both dissolution of drug and dissolution of drug through erosion of matrix tablet[10].
3. **Solution Solubility:** It is important to maintain in vivo (BIOLOGICAL) sink condition to study the release of drug in controlled manner solely by delivery system and is not affected by solubility factor[11].
4. **Polymer Diffusivity**[12]**:** The diffusion of small molecules in polymer structure is an energy activated process and the diffused particles move to a series of equilibrium position. The energy of activation Ed depends upon the length of polymer chain segment, cross linking and crystallanity of polymer. The release of drug may be attributed to three factors.
   - Polymer Particle Size
   - Polymer Viscosity
   - Polymer Concentration
5. **Thickness of Hydrodynamic Diffusion Layer:** It is observed that the drug release is the function of thickness of diffusion layer. The magnitude of drug release decreased when the thickness of diffusion layer is increased.

**Swellable Controlled Release Systems**[13,14,15]

During the release life of swellable matrix system, three fronts are generally expected.

1. The **swelling front**, the boundary between the still glassy polymer and its rubbery state.
2. **The diffusion front**, the boundary in the gel layer between the solid as yet undissolved, drug and the dissolved drug.
3. **The erosion front**, the boundary between the matrix and the dissolution medium. The measurement of front positions gives the possibility to determine three important parameters related to the behavior of the matrix i.e. the rate of water uptake, the rate of drug dissolution and the rate of matrix erosion associated with the movements of the swelling front, diffusion front and erosion front respectively.

The two polymers used in the study include:

I. **Xanthan gum** a high molecular weight, water soluble, anionic-bacterial hetero polysaccharide, used as a rheology modifier is derived a result of microbial fermentation of glucose from the bacterial coat of Xanthomonas campestris. It is a hydrophilic polymer, biocompatible and inert which along with retarding the drug release provides them time dependent release kinetics.

II. **Sodium alginate** is a natural polysaccharide obtained from marine brown algae, seaweeds as well as produced by some bacteria such as Pseudomonas aeruginosa or Azobacter vinelandi. It is a hydrophilic salt of alginic acid consisting of two uronic acids, β-D-mannuronic acid (M) and α-L-glucouronic acid (G). It is composed of homo polymeric blocks MM or GG.

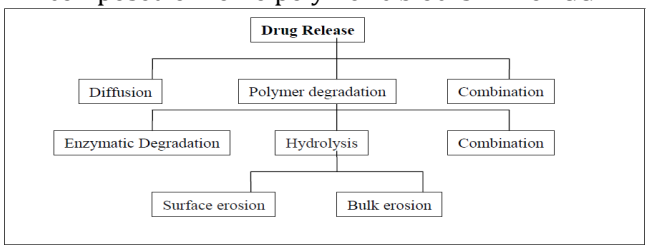


**Fig. 1**: Various mechanisms of drug release from the polymer matrix

## MATERIALS

Nishka Labs, Hyderabad, provided Nimodipine pure drug analytical grade along with excipients like Xanthan Gum, Microcrystalline Cellulose (MCC), Sodium alginate, Talc and Hydroxy-Poly-Methyl-Cellulose (HPMC). Mannitol, Sodium Chloride and Potassium Dihydrogen Ortho Phosphate were bought from SD Fine Labs Mumbai. Xanthan Gum, Sodium Alginate and MCC are three polymers whose ratios were optimized in the current study for preparation of Nimodipine Sustained release formulation.

## METHODS

The first step before formulating a tablet is the preformulation. Preformulation is defined as the phase of research and development process where physics, chemical and mechanical properties of a new drug substance are characterized alone and when combined with excipients in order to develop stable, safe and effective dosage form. A thorough understanding of physicochemical properties may ultimately provide a rationale for formulation design or support the need for molecular modification or merely confirm that there are no significant barriers to the compound development. Hence, preformulation studies were performed on the obtained sample of drug for solubility analysis, identification and compatibility studies.

### a) Solubility analysis

Preformulation solubility analysis was done, which include the selection of suitable solvent, to dissolve the respective drug as well as various excipients. The solubility was performed visually by dissolving in suitable solvents and water. The available literature on solubility profile of Nimodipine indicated that the drug is very soluble in methanol, DMSO, dioxane and ethanol and practically insoluble in water.

### b) Melting point determination:

Melting point is the temperature at which the pure liquid and solid exist in equilibrium. In practice, it is taken as equilibrium mixture at an external pressure of 1 atmosphere; this is sometimes known as normal melting points. The Thiel's tube method of melting point determination in liquid paraffin was used in the present study.

### Drug-Excipients Compatibility studies

Compatibility of drug (Nimodipine) and polymers which are used to prepare tablets was established by infrared absorption spectral analysis

### a) FTIR Spectral analysis

IR spectral analysis of pure drug Nimodipine, and excepients was carried out and observation was made whether changes in chemical constitution of drug after combining it with the polymers occurred. The samples were crushed with KBr to get pellets by applying pressure of 600 Kg/cm$^2$. Infra Red spectroscopy is one of the most powerful analytical techniques to identify functional groups of a drug.

### b) Differential scanning calorimetry (DSC) studies

Thermograms were obtained by using scanning colorimeter (Netzsch, 200F) ata heating rate 10°c/min. over a temperature range of 35-500°c. The sample washermetically sealed in an aluminum crucible. Nitrogen gas was purged at rate of 10 ml/min. for maintaining inert atmosphere.

### Calibration curve and determination of $\lambda_{max}$ of Nimodipine

The calibration curve for Nimodipine was prepared by using PBS 6.8 pH. The $\lambda_{max}$ of pure Nimodipine drug was determined using the UV Spectrophotometer and solvent as water.

## EVALUATION OF PRE COMPRESSION PARAMETERS

For a drug substance to formulate into a dosage form, it is necessary to study the physicochemical properties of the bulk drug.

### Determination of bulk density and tapped density

An accurately weighed quantity of the powder (W), was carefully poured into the graduated cylinder and the volume ($V_o$) was measured, then the graduated cylinder was closed with lid, set into the density determination apparatus. The density apparatus was set for 500 taps and after that, the volume ($V_f$) was measured and continued operation till the two consecutive readings were equal. The bulk density, and tapped density were calculated using the following formulas:

$$\text{Bulk density} = W / V_o$$

$$\text{Tapped density} = W / V_F$$

Where, W = weight of the powder, $V_0$ = initial volume, $V_F$ = final volume

### Flow Properties

Angle of repose of different formulations was measured by fixed funnel standing method. Granules were weighed and passed through the funnel, which was kept at a certain height from horizontal surface. The passed microspheres formed a pile of height 'h' above the horizontal surface and the pile was measured[6]. The angle of repose was determined by

$$\mathbf{Tan\ (\theta) = h / r}$$

$$\text{Angle of repose } (\theta) = Tan^{-1} (h / r)$$

Where h is the height of pile and r is radius

### Compressibility Index and Hausners Ratio

Compressibility is indirectly related to the relative flow rate, cohesiveness and particle size of a powder. The compressibility of a material can be estimated from the tap and bulk density measurements. It is represented as percentage. In theory, the less compressible material is

more flowable. Compressibility index were calculated using the formula

$$\text{Compressibility}[\%] = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}} \times 100$$

**Formulation of Nimodipine Sustained release Tablets**

The SR tablets were prepared by Wet Granulation Method, All the ingredients were weighed an mixed one by one. Table No 1: shows the composition of matrix tablet, first the drug, Lactose, Eudragit, HPMC were added to the motar and pistle. Thorough mixing was done and the ingredients were passed through #40 mesh. Blended with water to form a damp mass, passed through #20mesh, and dried at 40 º c and lubricants were added. Then the powder blend was compressed on a 9 Station Rotary compression machine by using 6mm circular shape punches.

**Table 1:** Formulation Table for Nimodipine Sustained Release Tablets

| Formu-lation Code | Drug NM | Xanthan gum | Sodium Alginate | HPMC K 15 | MCC | Talc | MAN | Total |
|---|---|---|---|---|---|---|---|---|
| NMP1 | 40 | 0 | 40 | 100 | 85 | 5 | 130 | 400 |
| NMP2 | 40 | 10 | 30 | 100 | 85 | 5 | 130 | 400 |
| NMP3 | 40 | 20 | 20 | 100 | 85 | 5 | 130 | 400 |
| NMP4 | 40 | 30 | 10 | 100 | 85 | 5 | 130 | 400 |
| NMP5 | 40 | 40 | 0 | 100 | 85 | 5 | 130 | 400 |
| NMP6 | 50 | 0 | 40 | 120 | 65 | 5 | 120 | 400 |
| NMP7 | 50 | 10 | 30 | 120 | 65 | 5 | 120 | 400 |
| NMP8 | 50 | 20 | 20 | 120 | 65 | 5 | 120 | 400 |
| NMP9 | 50 | 30 | 10 | 120 | 65 | 5 | 120 | 400 |
| NMP10 | 50 | 40 | 0 | 120 | 65 | 5 | 120 | 400 |

**Evaluation of post compression parameters for Nimodipine Sustained Release Tablets**

**a) Thickness**

Thickness of the Nimodipine was important for the uniformity of tablet. Thickness was measured using the Vernier callipers.

**b) Hardness**

Tablets require a certain amount of strength, or hardness and resistance to friability, to withstand mechanical shocks of handling in manufacture, packaging and shipping. The hardness of the tablets was determined using Monsanto Hardness tester.

**c) Friability**

It is the phenomenon whereby tablet surfaces are damaged and/or show evidence of lamination or breakage when subjected to mechanical shock or attrition. The friability of tablet was determined by using Veego Friabilator as per IP procedure of friability. It is expressed in percentage (%).

**d) Swelling Index**

The diameter of tablets was taken at intervals of five minutes until maximum diameter was attained with a digital Vernier caliper. Thereafter the swelling indices (SI) were calculated from initial diameter of tablet (D1) and maximum diameter on swelling in water (D2) as expressed below:

$$SI\ (\%) = D2/D1 \times 100$$

**e) In-Vitro Drug Release Studies**

*In-vitro* dissolution studies of Nimodipine tablets were performed using USP type-II (Paddle) Type dissolution test apparatus. 600ml of buffer is used as a dissolution medium. The medium was maintained at 37±0.5ºC at a speed of 50rpm. The *in vitro* dissolution studies were performed at two different pH in 0.01N HCl for 2 hrs. An accurately weighed sample was responded in dissolution medium consisting 900ml of buffer and dissolution was done up to 12hrs. At prefixed time intervals (every 1 hour); 5ml of sample was withdrawn and filtered through 0.4 µm membrane filter. The volume of the dissolution medium was adjusted to 900ml at every sampling time by replace same 5ml of dissolution medium. Then the samples were analyzed Spectrophotometrically at 451nm.

**Drug release mechanism of Nimodipine can be predicted by 'n' value shown in table:**

**Table 2:** Drug release

| Release exponent (n) | Drug release mechanism | Rate as a function of time |
|---|---|---|
| 0.5 | Fickian diffusion | $t^{-0..5}$ |
| 0.5 < n <1 | Anomalous transport | $t^{n-1}$ |
| 1 | Case-II transport | Zero order release |
| > 1 | Super case II transport | $t^{n-1}$ |

## RESULTS AND DISCUSSIONS

**1. Preformulation Studies**

**Organoleptic Characteristics**

The color, odor, and taste of the drug were characterized and recorded using descriptive terminology; the results were shown in the table

**Table 3:** Organoleptic Characteristics of Nimodipine

| Properties | Result |
|---|---|
| Odour | Odourless |
| Colour | Yellowish |
| Form | Crystalline |

**Melting point**

The melting point of the pure drug Nimodipine was observed as 125$^0$C similar to reported.

**Solubility analysis**

The available literature on solubility profile of Nimodipine indicated that the drug is very soluble in methanol, DMSO, dioxane and ethanol, practically insoluble in water. Nimodipine was found to be soluble in methanol, ethanol and DMSO. The study was carried out to select suitable dissolution medium for *in-vitro* release studies.

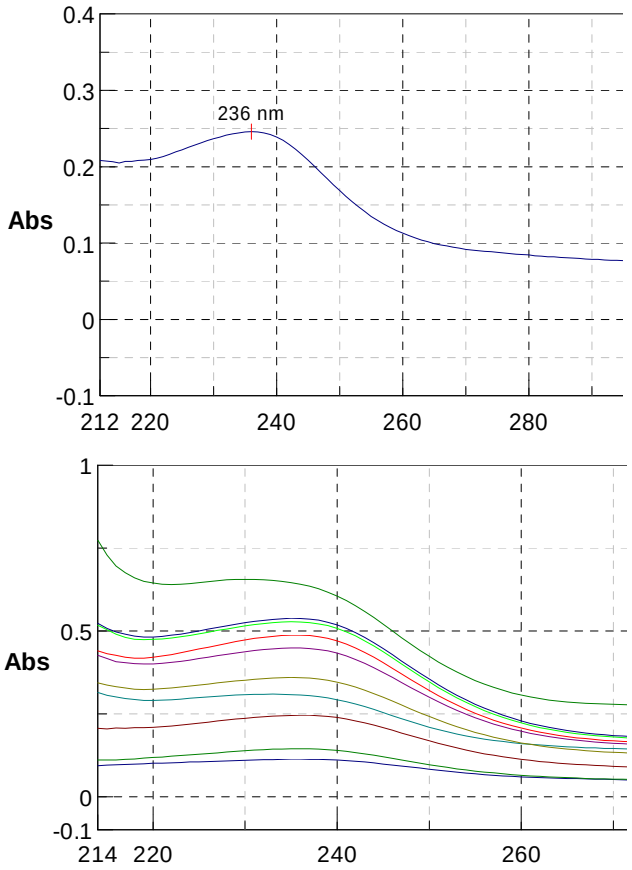


**Fig.2:** λmax of Nimodipine in pH 6.8 at 236nm and Overlay Spectrums of Nimodipine

**Table 4:** Observations for Standard graph of Nimodipine in pH 6.8 at 236nm

| Concentration (µg/ml) | Absorbance (236nm) in pH 6.8 |
|---|---|
| 2 | 0.09 |
| 4 | 0.145 |
| 6 | 0.236 |
| 8 | 0.289 |
| 10 | 0.345 |
| 12 | 0.421 |
| 14 | 0.48 |
| 16 | 0.52 |
| 18 | 0.568 |
| 20 | 0.65 |

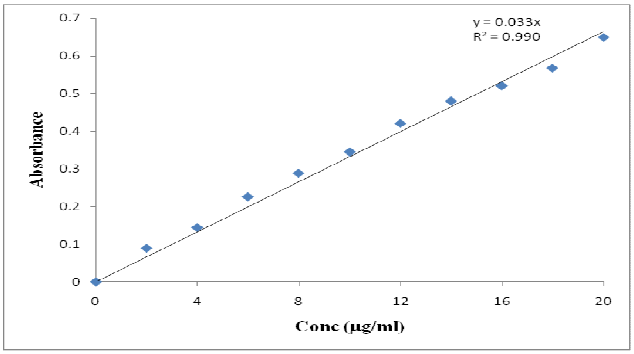


**Fig. 3:** Calibration curve of Nimodipine in pH 6.8 at 236nm

**Drug-excipient compatability study**

**1) FTIR Spectral analysis**

IR spectral analysis of pure drug Nimodipine, and excepients was carried out and observation was made whether changes in chemical constitution of drug after combining it with the polymers occurred. The samples were crushed with KBr to get pellets by applying pressure of 600 Kg/cm$^2$.

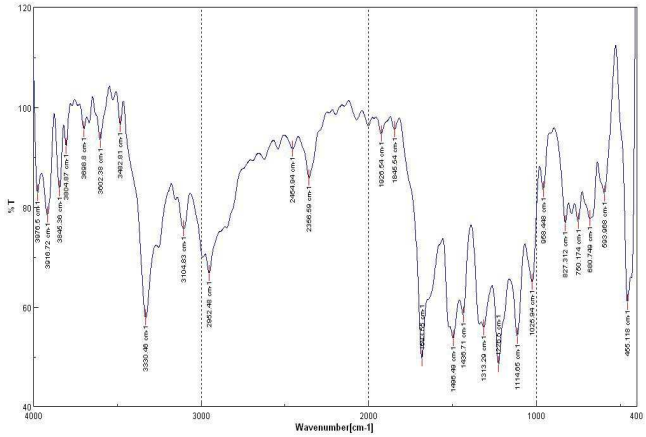


**Fig. 4:** IR Spectra of Nimodipine pure drug

**Table 5:** Nimodipine Pure drug peaks and wave number

| Formulation | Wave number |
|---|---|
| Nimodipine | 3976.5, 3916.72, 3845.36, 3804.87, 3698.8, 3602.38, 3482.21, 3330.48, 3104.83, 2952.48, 2454.942356.59, 1926.54, 1845.54, 1683.55 |

**2) DSC Analysis**

DSC thermo grams of Nimodipine, ethyl cellulose with their combination of drug with excipients are shown in figures. In case of Nimodipine two endothermic peaks were observed one at 173.6$^0$C, which corresponds to melting process. Combination of drug and excipients showed endothermic peak at 168.9$^0$C, it may be concluded that the drug has not shown any interaction with different polymers used in preparing the different formulations.

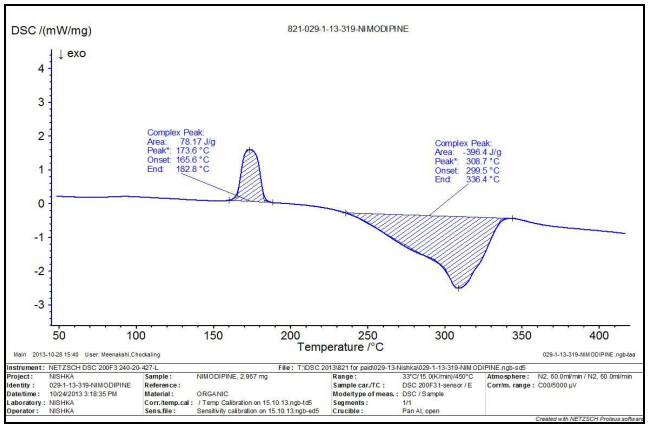


**Fig. 5:** DSC of Nimodipine Pure drug

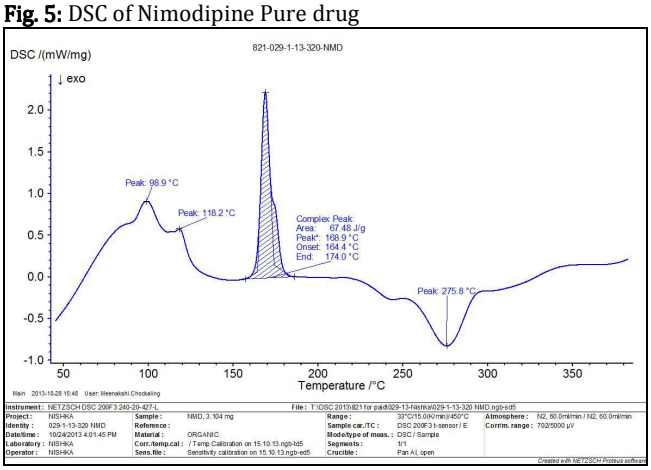


**Fig. 6**: DSC of Drug + Mixture

## Evaluation of Pre-compression Parameters of Nimodipine Sustained Release Tablets

### a) Determination of bulk density, tapped density and Powder flow Properties

The bulk density, tapped density, Hausner's ratio, Compressability index and angle of repose for the blend was performed and reported. The bulk density for Nimodipine blend of entire formulations varied from 0.563±0.006 to 0.583±0.006.Tapped density for Nimodipine blend was varied from 0.62±0.01 to 0.677±0.006 respectively. Bulk density and Tapped densities showed good packability of the granules. For Nimodipine blend the compressibility index for all formulations ranges from 8.455±0.684 to 19.416±0.769 respectively. NMP2 has lowest Carr's index indicating good compressibility. The Hausner's ratio for Nimodipine blend ranges from 1.062857±0.01 to 1.240964±0.011. The NMP5 is having lowest hausner's ratio indicating good flow property. Angle of repose for Nimodipine blends ranges from 22.1±0.367 to 28.82±0.99 respectively. These represents that the blend flows freely through the hopper.

**Table 6:** Powder Flow Properties for Nimodipine Sustained Release Tablets

| S.No | Formulation code | Hausner's ratio ±S.D | Carr's index± S.D | Angle of repose ± S.D |
|---|---|---|---|---|
| 1 | NMP1 | 1.123±0.003 | 10.99±0.266 | 26.83±0.942 |
| 2 | NMP2 | 1.092±0.008 | 8.455±0.684 | 25.98±0.86 |
| 3 | NMP3 | 1.1598±0.018 | 13.763±1.3 | 25.48±0.467 |
| 4 | NMP4 | 1.128±0.021 | 11.33±1.6 | 22.1±0.367 |
| 5 | NMP5 | 1.062857±0.01 | 5.9151±0.94 | 26.37±0.754 |
| 6 | NMP6 | 1.130178±0.009 | 11.51±0.69 | 28.06±0.398 |
| 7 | NMP7 | 1.08046±0.01 | 7.442876±0.868 | 23.617±0.646 |
| 8 | NMP8 | 1.162791±0.008 | 13.99287±0.617 | 28.06±0.398 |
| 9 | NMP9 | 1.121387±0.018 | 10.81731±1.4 | 27.64±0.92 |
| 10 | NMP10 | 1.109195±0.01 | 9.84127±0.817 | 21.83±0.895 |

## Evaluation of post compression parameters for Nimodipine Sustained Release Tablets

The thickness of Nimodipine tablet for all the formulations were in the range of 4.127±0.025 to 4.347±0.153. The hardness of all the tablets prepared by Wet Granulation method for Nimodipine tablet was within the range of 6.17±0.289 kg/cm² to 7.33±0.289 kg/cm². Tablet hardness was increased as increasing the compression force. This ensures good handling characteristics of all batches. The friability of all the prepared formulations was within the I.P limit. The % of Friability for tablet ranges from 0.43±0.025 to 0.69±0.025 respectively. The results were tabulated in Table No 7. The % Friability was NMT 1% in all formulations ensuring that the all the tablets were mechanically stable. The weight variation in tablet formulations was in the range of 399.741±1.742 to 400.844±0.564 mg. All the prepared tablets passed the weight variation test. The weights of all the tablets were found to be uniform with low standard deviation values. Swelling index was determined and shown in table 8.

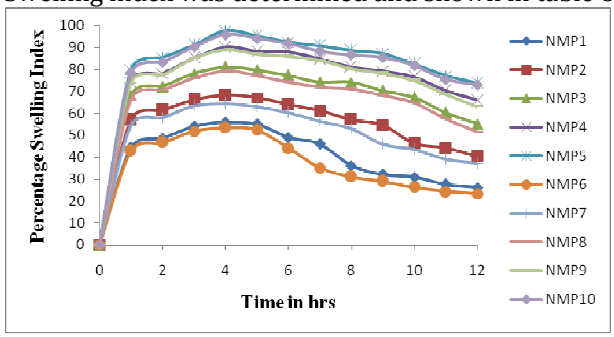


**Fig.7:** Swelling Index of Nimodipine Loaded Sustained Release Tablets For NMP1 To NMP10

**Table 7:** Evaluation of Hardness, Thickness, Weight variation, Drug content and friability of Nimodipine Sustained Release Tablets

| S. No | Formulation Code | Hardness ($kg/cm^2$) | Thickness (mm) | Avg.wt. of Tablet ±S.D (mg) | Friability ±S.D (%) | Drug Content±S.D (%) |
|---|---|---|---|---|---|---|
| 1 | NMP1 | 6.17±0.289 | 4.127±0.025 | 400.844±0.564 | 0.43±0.025 | 98.23±0.45 |
| 2 | NMP2 | 6.83±0.764 | 4.193±0.015 | 400.76±1.11 | 0.537±0.03 | 99.11±0.37 |
| 3 | NMP3 | 7.17±0.289 | 4.113±0.025 | 400.56±1.22 | 0.597±0.041 | 99.0±0.69 |
| 4 | NMP4 | 6.17±0.289 | 4.157±0.055 | 400.694±1.199 | 0.48±0.036 | 98.48±0.68 |
| 5 | NMP5 | 6.83±0.764 | 4.18±0.0264 | 400.469±1.084 | 0.48±0.01 | 99.52±0.39 |
| 6 | NMP6 | 6.67±0.289 | 4.19±0.045 | 400.029±1.304 | 0.51±0.02 | 100.67±0.48 |
| 7 | NMP7 | 6.33±0.289 | 4.137±0.064 | 400.395±1.362 | 0.61±0.038 | 99.38±0.47 |
| 8 | NMP8 | 7.33±0.289 | 4.17±0.02 | 400.498±0.947 | 0.5370.025 | 98.77±0.56 |
| 9 | NMP9 | 6.17±0.289 | 4.13±0.015 | 400.603±1.823 | 0.44±0.042 | 98.97±0.38 |
| 10 | NMP10 | 6.67±0.289 | 4.147±0.025 | 399.867±1.639 | 0.44±0.264 | 99.04±0.71 |

**Table 8:** Swelling Index of Nimodipine Loaded Sustained Release Tablets For NMP1 To NMP10

| Time (hrs) | Swelling Index (%) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NMP1 | NMP2 | NMP3 | NMP4 | NMP5 | NMP6 | NMP7 | NMP8 | NMP9 | NMP10 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 44.26 | 57.11 | 68.06 | 74.27 | 79.9 | 42.94 | 54.47 | 66.33 | 73.94 | 78.26 |
| 2 | 48.63 | 61.36 | 72.22 | 78.12 | 85.38 | 46.63 | 58.03 | 70.61 | 77.63 | 83.32 |
| 3 | 53.98 | 66.07 | 78.1 | 85.29 | 91.11 | 51.8 | 63.37 | 76.02 | 84.98 | 90.28 |
| 4 | 55.83 | 68.16 | 81 | 90.11 | 97.5 | 53.3 | 64.39 | 79.4 | 88.83 | 95.83 |
| 5 | 54.98 | 66.98 | 79.6 | 88.09 | 95.2 | 52.27 | 63 | 77.2 | 86.98 | 94.08 |
| 6 | 48.9 | 64.09 | 77.18 | 87.97 | 92.27 | 44.09 | 60.17 | 74.09 | 85.9 | 91.79 |
| 7 | 45.94 | 61.14 | 74.07 | 84.66 | 90.84 | 35.14 | 56.49 | 71.8 | 83.94 | 88.24 |
| 8 | 36.13 | 57.08 | 73.94 | 81.13 | 88.61 | 31.13 | 53 | 70.96 | 80.13 | 86.63 |
| 9 | 32.19 | 54.47 | 70.38 | 79.12 | 87.17 | 29.06 | 45.99 | 68.16 | 78.19 | 85.44 |
| 10 | 30.87 | 46.27 | 67.17 | 76.57 | 82.37 | 26.17 | 43.57 | 64.57 | 74.87 | 81.68 |
| 11 | 27.63 | 44.13 | 60.24 | 70.21 | 77.13 | 24.36 | 39.13 | 57.23 | 68.63 | 75.3 |
| 12 | 25.98 | 40.2 | 55.16 | 65.98 | 73.68 | 23.32 | 37.08 | 51.45 | 62.98 | 72.9 |

**Invitro Drug Release**

**Table 9: Regression and Slope Data of Release Kinetics of Nimodipine SR Tablets**

| Formulation code | Swelling Index (t=12 hrs) | Mathematical models (release kinetics) | | | | |
|---|---|---|---|---|---|---|
| | | Zero order kinetics | Firstorder kinetics | Higuchi's | Peppa's | |
| | | $r^2$ | $r^2$ | $r^2$ | $r^2$ | n |
| NMP1 | 25.98 | 0.981 | 0.873 | 0.949 | 0.985 | 0.896 |
| NMP2 | 40.2 | 0.983 | 0.749 | 0.967 | 0.99 | 0.645 |
| NMP3 | 55.16 | 0.99 | 0.87 | 0.956 | 0.995 | 0.734 |
| NMP4 | 65.98 | 0.996 | 0.911 | 0.938 | 0.998 | 0.881 |
| NMP5 | 73.68 | 0.996 | 0.933 | 0.921 | 0.989 | 1.12 |
| NMP6 | 23.32 | 0.98 | 0.868 | 0.949 | 0.985 | 0.896 |
| NMP7 | 37.08 | 0.983 | 0.946 | 0.938 | 0.984 | 1.02 |
| NMP8 | 51.45 | 0.989 | 0.86 | 0.959 | 0.994 | 0.714 |
| NMP9 | 62.98 | 0.995 | 0.904 | 0.944 | 0.998 | 0.843 |
| NMP10 | 72.9 | 0.998 | 0.925 | 0.919 | 0.991 | 1.05 |

## SUMMARY AND CONCLUSION

These considerations indicate that hydrophilic polymers have the potential to sustain the release of drug from matrix tablets. The release of drug is retarded as concentration of gum increases in all formulation. In order to investigate the effect of polymer type and percentage on drug release profile, different formulations containing various percentages of Xanthan gum and Sodium alginate was used. All these natural gum is hydrophilic cellulose ether, which is used as a retarding release of drug in controllable manners up to 12 hrs. The above results indicated that the formulations NMP1 to NMP5 are containing 40mg of drug with a combination of different excipients. The drug release showed in NMP1 was 97.49%, for only

11hrs because there was a absence of Xanthan Gum and NMP2 showed 98.65% within 11hrs. The Nimodpine tablets of NMP3, NMP4 and NMP5 showed drug release of 93.74%, 88.34% and 83.83% for 12hrs. From these five formulations it was concluded that increase in concentration of Xanthan Gum there was a decrease in drug release.

## REFERENCE

1. C. S. L. Chalo, J. R. Robinson, V. H. L. Lee. Sustained Release Drug Delivery Systems, Remington's Pharmaceutical Sciences, 17th ed. Mack, 1995.
2. D. M. Brahmankar S. B. Jaiswal. Biopharmaceutics and Pharmacokinetics a Treatise, 1st ed New Delhi, Vallabh Prakashan, 1995.
3. Y. W. Chein. Novel Drug Delivery Systems, 2 ed. New York, Marcel Dekker, 1992.
4. N. K. Jain NK. Controlled and Novel Drug Delivery, 1st ed New Delhi, CBS Publishers and Distributors, 1997.
5. S. P. Vyas, R. K. Khar. Text Book of Controlled Drug Delivery, 1st ed. Vallabh Prakashan, 2002.
6. J. R. Robinson, V. H. L. Lee. Controlled Drug Delivery: Fundamentals and Applications, 2nd ed. New York, Marcel Dekker, 1978.
7. J. K. Lalla. Introduction to Controlled Release and Oral Controlled Drug Delivery System, The Eastern Pharmacist 45: 25-28 (1991).
8. G. M. Jantzen, J. R. Robinson, G. S. Banker, C. T. Rhode. Sustained and Controlled Release Drug Delivery, 3rd ed. Marcel Dekker, 1996.
9. K. Takada, K. H. Yoshi. Oral drug delivery–Traditional, Encyclopedia of Controlled Release Drug Delivery, John Wiley and Sons Inc; 1999.
10. P. Colombo. Swelling controlled release in hydro gel matrices for oral route, Adv Drug Del Review 37-57 (1993).
11. C. S. Satish, K. P. Satish, H. G. Shivkumar. Hydrogel as Controlled Drug Delivery System: synthesis, cross linking, water and drug transport mechanism, Indian J Pharm Sci 68(2): 133-40 (2006).
12. A. Harrower. Gliclazide modified release: from once daily administration to 24- hour blood glucose control, W. B. Saunders Company 2000.
13. H. Abdelkader, O. Y. Abdalla, H. Salem. Formulation of controlled-release baclofen matrix tablets: Influence of some hydrophilic polymers on the release rate and in vitro evaluation, AAPS Pharm Sci Tech 8: 4 (2007).
14. K. D. Tripathi. Essentials of medical pharmacology, 4th edition, updated reprint 2001 pp. 157.
15. R. C. Rowe, P. J. Sheskey, M. E. Quinn. Handbook of Pharmaceutical excipients, 2009.