ORIGINAL ARTICLE e-ISSN: 2349-0659 p-ISSN; 2350-0964

# Formulation and Evaluation of Nimodipine Tablets Using Solid Dispersion Technique

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## Abstract

The present study is an attempt to develop immediate release tablets of Nimodipine using solid dispersion technique to achieve rapid release in GIT which might result in enhanced absorption and thereby improved bioavailability. Various batches of Nimodipine solid dispersion (SD1-SD6) were prepared using fusion method, solvent evaporation and combination of these two methods (melt evaporation method/melting solvent method). PEG 6000 and PVP K30 were used as polymeric carrier in (drug: carrier) 1:1 ratio for all the formulations. Docusate sodium was used as surfactant in 0.025% to 0.085%. Drug-excipients interactions were carried out for pure drug and optimized formulations using FTIR studies. Six batches of Nimodipine immediate release tablets (F1 to F6) were developed by wet granulation method using its solid dispersion. Crospovidone was selected as super disintegrant and acetone as an organic solvent. All the batches of immediate release tablets were evaluated for different pre-compression and post-compression parameters including stability study of the optimized formulation. Among all formulations, F6 prepared by melt evaporation method with a high surfactant content showed the greatest drug release (101.49% ± 0.31%). The stability studies (formulation F6) showed there was no major differences in physical parameters and was stable even after a period of 3 months. % CDR of the accelerated time stability batch was 94.41% ± 0.265% of its content in 30 min which is showing immediate release and the drug content of the same stability batch was 99.87% ± 0.119%.

**Keywords:** Docusate Sodium, Nimodipine, PEG 6000, PVPK 30, Solid dispersion methods

*Asian Pac. J. Health Sci.*, (2022); DOI: 10.21276/apjhs.2022.9.4.66

## Introduction

Oral drug delivery is the easiest and most convenient route for administering drugs. Although, increased focus and interest are generated within the area of controlled release and targeted drug delivery system in recent years, many patients require quick onset of action particularly therapeutic condition and consequently immediate release of medicaments are required which are intended to be swallowed whole, disintegrate and release their medicament immediately.

The formulation of poorly soluble compounds, typically biopharmaceutical classification system Class II drugs, that exhibit low water solubility and high membrane permeability for oral administration is currently one of the most common and major challenges faced by formulation scientists in the pharmaceutical industry.[1] Almost 40% of potential new drugs identified by the pharmaceutical industry are poorly water soluble.

A number of strategies have been worked on to overcome the poor water solubility crisis, such as chemical modification, changing solvent composition, use of a carrier system, and physical modification including the solid dispersion method. Among all technologies, solid dispersion technology stands out as the most promising approach that increases the solubility of poorly soluble drugs.[2]

Chiou and Reigelman first defined solid dispersion as a dispersion of one or more active ingredients in an inert carrier or solid-state (hydrophilic) matrix prepared by melt, solvent, or melt evaporation processes[3-5] or solid dispersion is defined as a dispersion involving the formation of eutectic mixtures of drugs with carriers that are easily soluble in water by melting their physical mixtures.[6,7] Solid dispersion consists of a hydrophobic drug dispersed in at least one hydrophilic carrier, resulting in an increased surface area, resulting in higher drug solubility, and dissolution rate. Improving wettability and dispersability[8] reducing aggregation and agglomeration of drug particles result in improved drug bioavailability.

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**How to cite this article:** Kandwal M, Ghalan I, Patil S. Formulation and Evaluation of Nimodipine Tablets Using Solid Dispersion Technique. Asian Pac. J. Health Sci., 2022;9(4):355-364.

**Source of support:** Nil.

**Conflicts of interest:** None.

**Received:** 04/03/2022 **Revised:** 12/04/2022 **Accepted:** 19/05/2022

### Nimodipine

Nimodipine is 1, 4-dihydropyridine derivative L-type calcium channel blocker proposed in the prevention of ischemic neurological deficits following aneurysmal subarachnoid hemorrhage from ruptured congenital aneurysms.[9] It acts as an antihypertensive agent, a calcium channel blocker, a vasodilator agent, and a cardiovascular drug.

The major problem of this drug is very low solubility in biological fluids and poor oral bioavailability. The drug is having oral bioavailability around 13% and half-life of 9 h.[10] A number of solid dispersion methodologies can be adapted to improve solubilization of poor water soluble drug and further to improve

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its bioavailability. Different methods for the production of solid dispersions are melting process, solvent evaporation process, melt evaporation process, kneading process, spray drying process, co-grinding process, freeze drying process, hot melt extrusion, melt agglomeration, and supercritical fluid technology. Among all solid dispersion methods, melting method, solvent evaporation method, and melt evaporation method/melting solvent method are widely used on laboratory and industrial scale.

The aim of present work is to develop an immediate release Nimodipine tablets using its solid dispersion formulated by fusion, solvent evaporation, and melting solvent method where polymeric materials and surfactant act as effective carriers for enhancing the dissolution profile, absorption efficiency, and bioavailability of water insoluble drug Nimodipine.

## Materials and Methods

Nimodipine and all other excipients were donated by Meera Biotech Pvt. Ltd., Nepal. Thermax Pvt. Ltd. is the manufacturer of PVPK 30 and Crospovidone. Accent Microcell Pvt. Ltd is the manufacturer of MCC 101 and Magnesium stearate. Starch was supplied by Orient Pharma and Aerosil by Shree Chemicals. All the manufacturing equipments were available in Analytical R&D departments of Meera Biotech Pvt. Ltd. All reagents used were of analytical grade.

### Preformulation Studies

#### *Solubility studies*

The solubility study of Nimodipine was performed in water and various other solvents such as acetone, ethanol, and ethyl acetate. Saturated solutions were prepared by adding drug to the vehicles and shaken on sonicator for 1 h at 25°C under constant vibration. Filtered sample (1 ml) was diluted appropriately with 0.1N HCL solution and Nimodipine was determined spectrophotometrically at 340 nm using UV-visible spectrophotometer.

The solubility study of Nimodipine in different water soluble carriers such as PEG 6000, PVPK 30, HPMC, Tween 80, SLS, Glycerin, and Docusate Sodium was performed. An excess amount of pure drug was added to 25 ml of aqueous solution of above mentioned water soluble carriers. The sample solutions were shaken on sonicator for 1 h at 25°C under constant vibration. After 1 h saturated solution was filtered through a Whatman filter paper and analyzed by UV spectrophotometer at 340 nm.

#### *FTIR studies*

FTIR Spectra were studied to confirm the compatibility of the API with the excipients. FTIR spectroscopy was obtained by the FTIR spectrophotometer using physical mixture of drug to excipient ratio at 1:1 and the scanning range used was 4000 to 650 cm-1[11] at a scan period of 1min.

### Preparation of Nimodipine Solid Dispersion

#### *Fusion/melting method*

Weight accurately Nimodipine and polymeric carrier (PEG 6000) in the ratio of 1:1. Place the polymer into a china dish and heat it on a water bath with continuous stirring until the polymer is dissolved. Add drug in dissolved polymer solution with continuous stirring to form a mixer. After complete mixing of drug and polymer rapidly transfer into the ice bath to solidify with vigorous stirring. Then, the final solid mass is crushed, pulverized, and sieved.

#### *Solvent evaporation method*

Weight accurately Nimodipine and polymeric carriers (PVPK 30, PEG 6000) in the ratio of 1:1. Dissolve drug and polymeric material in a common organic volatile solvent acetone. The solvent is evaporated at room temperature and dried in hot air oven at 50°C for 4 h. The resultant mass is passed through sieve number 60 and stored in desiccators.

#### *Melt evaporation method/melting solvent method*

Weight accurately Nimodipine and polymeric carrier (PEG 6000) in the ratio of 1:1. Dissolve 0.02% to 0.08% surfactant (Docusate sodium) in acetone which is a liquid solvent and keep aside. Melt PEG 6000 on a water bath maintaining low temperature of around 50°C. Add drug to this molten PEG 6000 slowly and stirred vigorously. Finally, add acetone and surfactant mixed solution to this drug and molten PEG mixture. The solvent is evaporated at room temperature and dried in hot air oven at 50°C for 4 h. The resultant mass is passed through sieve number 60 and stored in desiccators.

Six different batches were formulated as shown in Table 1.

### Evaluation of Nimodipine Solid Dispersion

#### *Percentage practical yield*

Percentage practical yield was calculated to know about percent yield or efficiency of any method, thus its help in selection of appropriate method of production. SDs were collected and weighed to determine practical yield from the following equation.[12]

$$\% \text{ Practical yield} = \frac{\text{Practical mass (Solid dispersion)}}{\text{Theoretical mass} \begin{pmatrix} \text{drug} + \text{Polymer} \\ + \text{Surfactant} \end{pmatrix}} \times 100$$

**Table 1:** Formulation of different batches of Nimodipine solid dispersion

| *S. No.* | *MATERIALS* | *F1 (mg)* | *F2 (mg)* | *F3 (mg)* | *F4 (mg)* | *F5 (mg)* | *F6 (mg)* |
|---|---|---|---|---|---|---|---|
| 1 | Nimodipine | 60.00 | 60.00 | 60.00 | 60.00 | 60.00 | 60.00 |
| 2 | PEG 6000 | 60.00 | – | 60.00 | 60.00 | 60.00 | 60.00 |
| 3 | PVPK 30 | – | 60.00 | – | – | – | – |
| 4 | Docusate sodium | – | – | – | 0.15 | 0.20 | 0.50 |
| | | – | – | – | 0.025% | 0.033% | 0.085% |
| Solid dispersion method | | Melting SD1 | Solvent evaporation SD2 | Solvent evaporation SD3 | Melting solvent SD4 | Melting solvent SD5 | Melting solvent SD6 |

*Dissolution studies*[13]

60 mg of pure Nimodipine and SDs prepared by fusion, solvent evaporation and melting method containing 60 mg Nimodipine were accurately weighed. Dissolution studies were carried out as per British Pharmacopoeia using USP apparatus type 2 at 75 rpm. Dissolution medium consist of 900 ml of acetate buffer pH 4.5 containing 0.3% w/v of SLS maintained at 37°C. The temperature of the dissolution medium was maintained constant at 37°C ± 0.5°C throughout the study. Samples of about 10 ml were pipette out at regular time intervals at 5, 10, 15 and 30 min. The sink condition was maintained by replacing with an equal volume of fresh dissolution medium. The withdrawn aliquots were filtered through Whatman filter paper 0.45 µ, suitably diluted and analyzed for drug content using a UV-Visible Spectrophotometer at 340 nm. A calibration curve was performed with R2 value equals 0.99, with the linear range of Nimodipine concentration (6–36) µg/ml, the used solvent was acetate buffer and suitable dilution was performed.

## Formulation of Immediate release Nimodipine SD Tablets

Six different batches were formulated as shown in Table 2.

Wet granulation technique was used for the preparation of tablet. Following steps were involved in the development of Nimodipine tablet:

- All the ingredients were sieved through #60
- After sieving, all the ingredients were mixed for 10 min
- The mixed content was granulated with Nimodipine solid dispersion using acetone
- The formed granules were sieved through #10
- Wet granules were dried in hot air oven at 50°C till the moisture content reaches below 4%
- The dried granules were sieved through #20
- The lubricants were sieved through #60 and mixed for 5 min.

The optimized formulation was aqueous film coated using Instacoat universal and Indigo Carmine Lake. The picture of the optimized formulation tablets is shown in Figure 1.

## Evaluation of Immediate release Nimodipine SD Tablets

*Pre-compression studies*

Determination of angle of repose

Angle of repose is an indication of the frictional forces excited between granule particles. It is the maximum angle possible between the surface of the pile of granules and the horizontal plane. Angle of repose was calculated using the following equation;

$$\text{Tan } \theta = h/r$$

Where,

$\theta$ = The angle of repose

h = Height of the heap of the powder

r = Radius of the heap of the powder

## Determination of Bulk Density and Tapped Density

20 g of the mixed blend (W) was introduced into a 100 ml measuring cylinder, and the initial volume was observed. The cylinder was allowed to fall under its own weight onto a hard surface from the height of 2.5 cm at 2 sec intervals. The tapping was continued until no further change in volume was noted. The bulk density and tapped density were calculated using the following equations;

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

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

Where,

W = Weight of the initial granules

$V_O$ = Initial volume of the granules

$V_F$ = Final volume of the granules

## Hausner's Ratio

It indicates the flow properties of the granules and is measured by the ratio of tapped density to the bulk density. Lower Hausner's ratio indicates better flow properties.

**Figure 1:** Nimodipine Tablets

**Table 2:** Formulation of different batches of Nimodipine SD tablets

| *S. No.* | *MATERIALS* | *F1 (mg)* | *F2 (mg)* | *F3 (mg)* | *F4 (mg)* | *F5 (mg)* | *F6 (mg)* |
|---|---|---|---|---|---|---|---|
| 1. | Nimodipine | 60.00 | 60.00 | 60.00 | 60.00 | 60.00 | 60.00 |
| 2. | PEG 6000 | 60.00 | – | 60.00 | 60.00 | 60.00 | 60.00 |
| 3. | PVPK 30 | – | 60.00 | – | – | – | – |
| 4. | Docusate Sodium | – | – | – | 0.15 | 0.20 | 0.50 |
| | | – | – | – | 0.025% | 0.033% | 0.085% |
| 5. | MCC 101 | 270.00 | 270.00 | 270.00 | 270.00 | 270.00 | 270.00 |
| 6. | Crospovidone | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 | 40.00 |
| 7. | Starch | 144.00 | 144.00 | 144.00 | 144.00 | 144.00 | 144.00 |
| 8. | Aerosil | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 |
| 9. | Acetone | q.s. | q.s. | q.s. | q.s. | q.s. | q.s. |
| Lubricants | | | | | | | |
| 10. | Crospovidone | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| 11. | Aerosil | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| 12. | Magnesium stearate | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Total | | 610.00 | 610.00 | 610.00 | 610.00 | 610.00 | 610.00 |

$$\text{Hausner's Ratio} = T/B$$

Where,
T = Tapped density
B = Bulk density

## Compressibility index (Carr's Index)

It is the indication of the compressibility of a powder. It is expressed in percentage. In theory, the less compressible a material the more flowable it is. A material having values of <20% have good flow property. Carr's Index (CI) was calculated using the following equation;

$$CI = (T\text{-}B/T) \times 100$$

Where,
CI = Carr's Index
T = Tapped density
B = Bulk density

## Post-Compression Studies

### *Weight variation*

The USP weight variation test was done by weighing 20 tablets individually, calculating the average weight and comparing the individual weights to the average.

### *Tablet hardness*

The hardness of each batch of tablet was checked using digital hardness tester. The hardness was measured in terms of Newton. Five tablets were chosen randomly and tested for hardness. The average hardness of five determinations was recorded.

### *Friability*

20 tablets were weighed and the initial weight of these tablets was recorded and placed in Roche friabilator and rotated at the speed of 25 rpm for 100 revolutions. Then tablets were removed from the friabilator dusted off the fines and again weighed and the weight was recorded. Percentage friability was calculated using the equation;

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

### *Tablet thickness*

Thickness of the tablet was measured using Vernier Calipers. It was determined by checking the thickness of ten tablets of each formulation.

### *Disintegration time*

Disintegration time for tablets was determined using USP disintegration apparatus. Six tablets were placed in six tubes of basket rack assembly, then, basket rack assembly is placed in 1000 ml beaker containing 900 ml of distilled water at 37°C ± 2°C and time required for complete disintegration of a tablet was measured.

### *In vitro dissolution studies*

60 mg of pure Nimodipine and tablet containing 60 mg Nimodipine were accurately weighed. Dissolution studies were carried out as per British Pharmacopoeia using USP apparatus type 2 at 75 rpm. Dissolution medium consist of 900 ml of acetate buffer pH 4.5 containing 0.3% w/v of SLS maintained at 37°C. The temperature of the dissolution medium was maintained constant at 37°C ± 0.5°C throughout the study. Samples of about 10 ml were pipette out at regular time intervals at 5, 10, 15 and 30 min. The sink condition was maintained by replacing with an equal volume of fresh dissolution medium. The withdrawn aliquots were filtered through Whatman filter paper 0.45 μ, suitably diluted and analyzed for drug content using a UV-Visible Spectrophotometer at 340 nm. A calibration curve was performed with R2 value equals 0.98, with the linear range of Nimodipine concentration (6–36) μg/ml, the used solvent was acetate buffer and suitable dilution was performed.

### *Drug content/assay*

20 tablets were weighed and powdered. The percentage drug content in tablet was estimated by using HPLC as per British Pharmacopoeia using the solution of 0.6% w/v of Nimodipine in methanol. 60 mg of Nimodipine was dissolved in 50 ml of methanol, mixed thoroughly by shaking with the aid of ultrasound for 5 min and the volume was made-up to 100 ml with methanol. The solution was centrifuged, filtered and the filtrate was diluted suitably with methanol and average content of Nimodipine was determined from obtained absorbance area. The drug content was calculated using the equation;

$$\text{Drug Content} = \frac{\text{Sample Absorbance (Area)}}{\text{StandardAbsorbance (Area)}} \times \frac{\text{Standard Weight}}{\text{Sample Weight}} \times \text{Dilution} \times \frac{\%\text{ potency ofStandard}}{100} \times 1000 \times \text{Average Weight}$$

The percentage drug content was calculated using the equation;

$$\text{Drug Content}(\%) = \frac{\text{Theoretical drug content}}{\text{Theoretical drug content}} \times 100$$

### *Stability studies*

Stability can be defined as the capacity of drug product to remain within specifications established to ensure its identity, strength, quality, and purity. The optimized formulation was aqueous film coated and subjected for 3 months stability study according to ICH guidelines. The selected formulations were packed in aluminum foil in tightly closed container. They were then stored at 30°C/75% RH (real time stability study) and 40°C/75% RH (accelerated time stability study) for 3 months and evaluated for percentage drug content and *in vitro* dissolution studies.[14]

## Result and Discussion

### Preformulation Studies

#### *Solubility studies*

Nimodipine is practically insoluble in water. It is freely soluble in ethyl acetate, soluble in acetate buffer pH 4.5, sparingly soluble in ethanol and slightly soluble in acetonitrile. The solubility study performed in different carriers is represented in Figure 2.

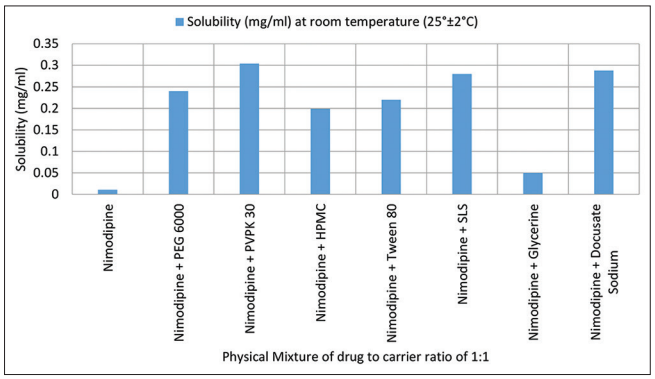


**Figure 2:** Solubility of Nimodipine in various carriers

### FTIR Studies

FTIR spectra for pure Nimodipine and its combination with different excipients are shown in Figures 3-11. Drug excipient compatibility study with FTIR spectra study revealed that, there was no interaction between drug and excipients. Therefore, excipients used in the formulation were compatible with Nimodipine.

### Evaluation of Nimodipine Solid Dispersion

#### *Percentage practical yield*

The percentage practical yield of Nimodipine solid dispersion is represented in Figure 12. The yield was found higher in the formulation SD6.

#### *Dissolution studies*

Figure 13 is the graphical representation of the drug release data. It showed the cumulative percent drug released as a function of time for all formulations. *In vitro* studies reveal that there is marked

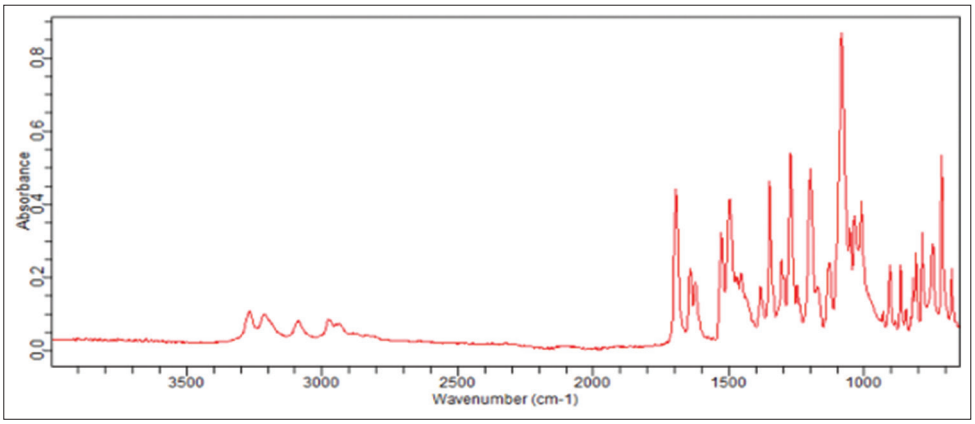


**Figure 3:** FTIR Spectra of Nimodipine

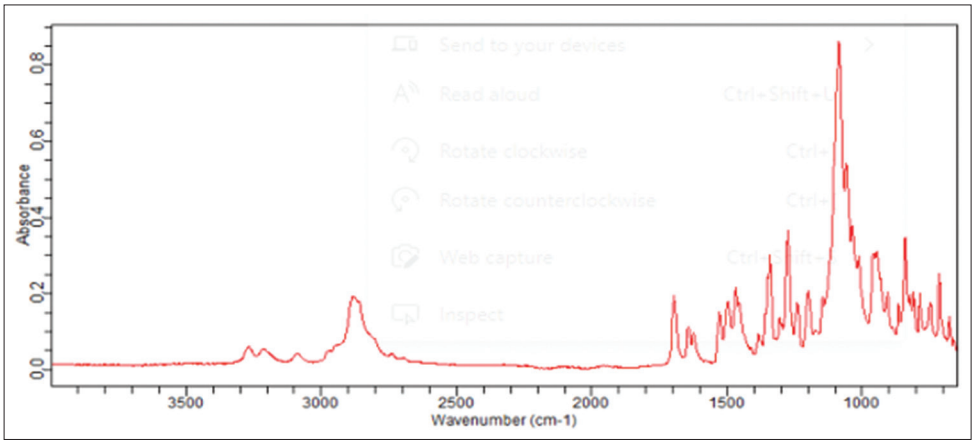


**Figure 4:** FTIR Spectra of Nimodipine + PEG 6000

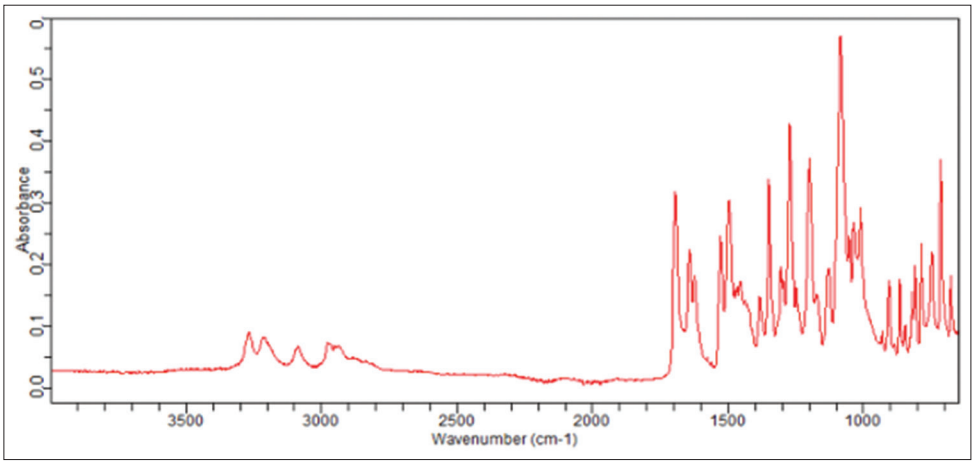


**Figure 5:** FTIR Spectra of Nimodipine + PVPK 30

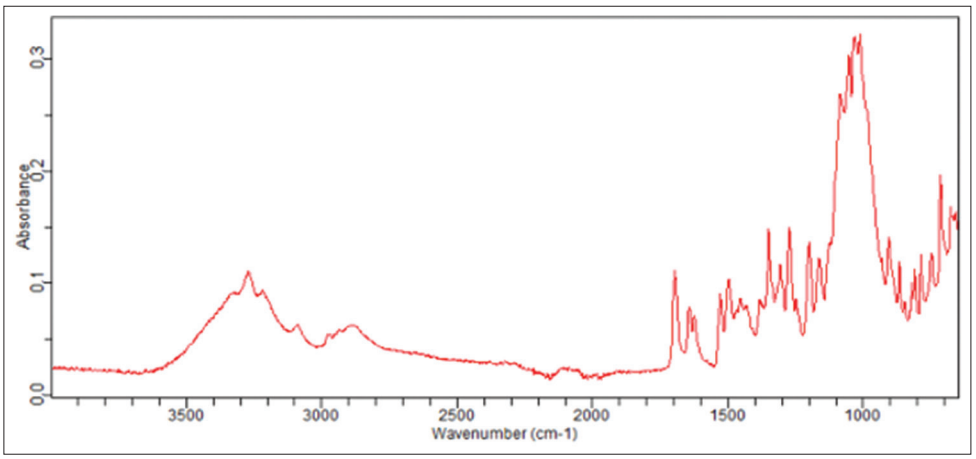


**Figure 6:** FTIR Spectra of Nimodipine + MCC 101

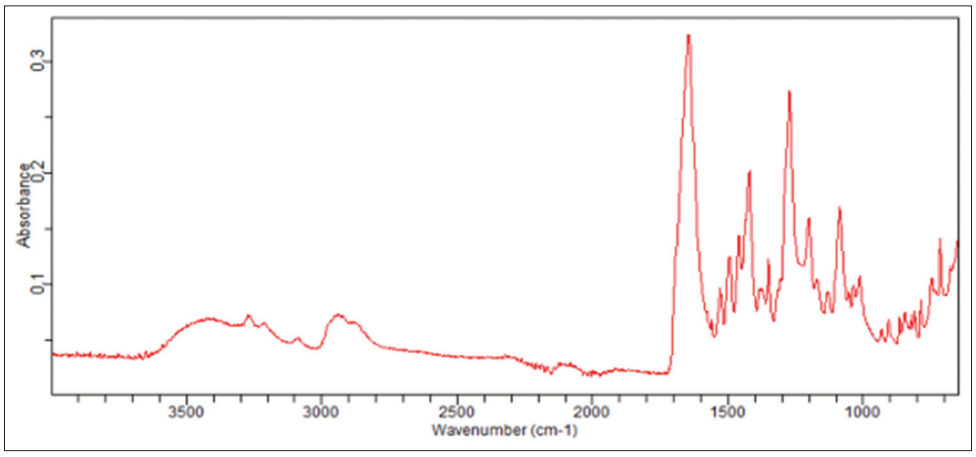


**Figure 7:** FTIR Spectra of Nimodipine + Crospovidone

increase in the dissolution rate of poorly soluble Nimodipine. From the *in vitro* drug release profile, it can be seen that formulation SD6 prepared by melt evaporation method with surfactant docusate sodium in 0.085% showed higher dissolution rate 86±4.15% compared with all other formulations. Increase in drug wettability, conversion to amorphous form, and solubilization of the drug have all helped in enhancing the solubility of the final formulation.

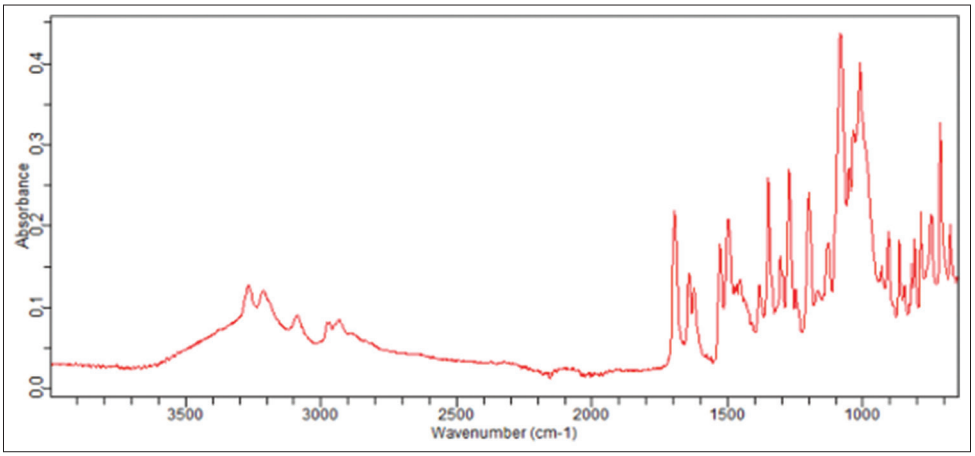


**Figure 8:** FTIR Spectra of Nimodipine + Starch

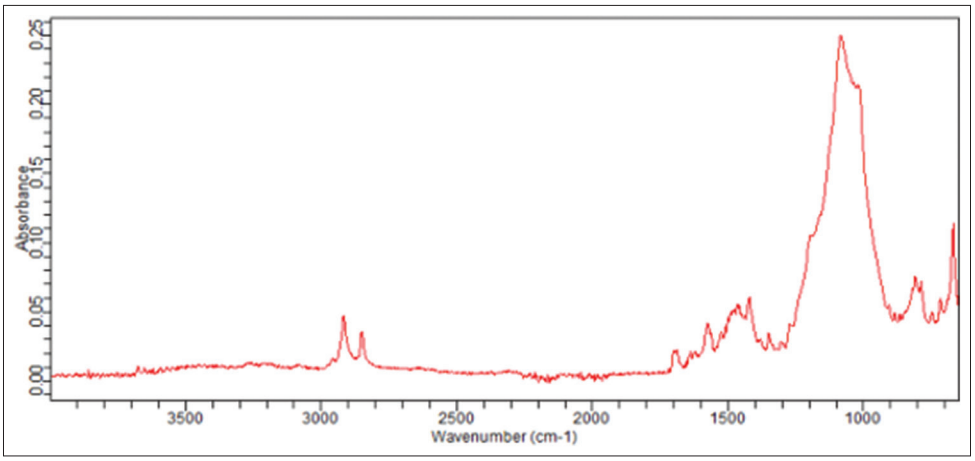


**Figure 9:** FTIR Spectra of Nimodipine + Aerosil

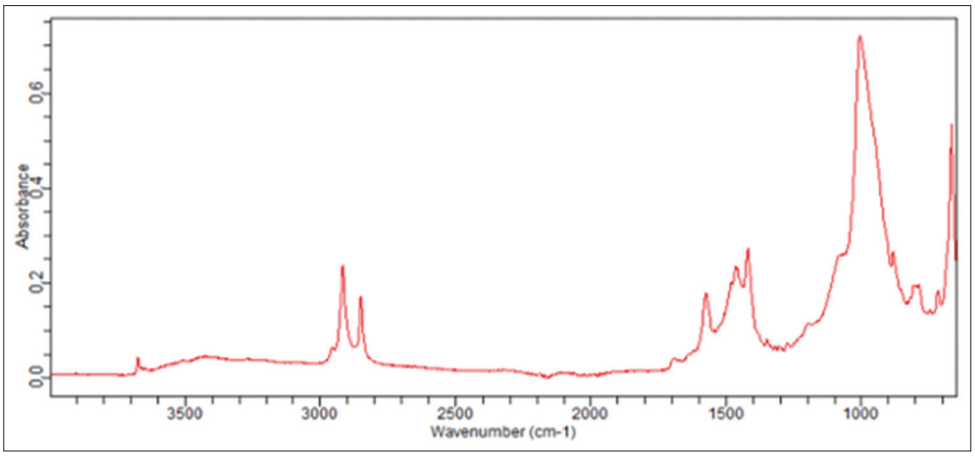


**Figure 10:** FTIR Spectra of Nimodipine + Magnesium Stearate

## Evaluation of Immediate release Nimodipine SD Tablets

### *Pre-compression studies*

The results for various pre-compression parameters are shown in Table 3. All the pre compression parameters of formulations F1 to F6 complied to standards.

### *Post-compression studies*

The results for various post-compression parameters are shown in Table 4. All the post compression parameters of formulations F1 to F6 such as hardness, thickness, friability and drug content confirmed to Pharmacopoeia standards. Among all formulations, F6 showed the highest drug content (97.96% ± 0.19%).

**Table 3:** Pre-compression parameter results

| *Code* | *Bulk density (g/cm³)* | *Tapped density (g/cm³)* | *Carr's index (%)* | *Hausner's ratio* | *Angle of repose (°)* |
|---|---|---|---|---|---|
| F1 | 0.378±0.025 | 0.467±0.020 | 19.057±0.025 | 1.235±0.030 | 31.460±0.020 |
| F2 | 0.478±0.030 | 0.786±0.025 | 39.186±0.040 | 1.644±0.035 | 30.370±0.035 |
| F3 | 0.357±0.015 | 0.417±0.030 | 14.388±0.040 | 1.168±0.030 | 24.188±0.002 |
| F4 | 0.477±0.020 | 0.591±0.025 | 19.289±0.035 | 1.240±0.025 | 34.830±0.035 |
| F5 | 0.428±0.035 | 0.513±0.040 | 16.569±0.085 | 1.199±0.045 | 26.820±0.030 |
| F6 | 0.432±0.040 | 0.513±0.0275 | 15.789±0.155 | 1.187±0.045 | 25.826±0.045 |

**Table 4:** Post-compression parameter results

| *Code* | *Thickness (mm)* | *Hardness (N)* | *Friability (%)* | *Weight variation (mg)* | *Drug content (%)* | *Disintegration time (sec)* |
|---|---|---|---|---|---|---|
| F1 | 5.53±0.02 | 173.01±4.03 | 0.01±0.001 | 610±5.00 | 94.24±0.04 | 260±2 |
| F2 | 5.71±0.03 | 130.15±3.04 | 0.02±0.001 | 609±8.00 | 96.50±0.04 | 200±3 |
| F3 | 5.58±0.04 | 166.30±5.03 | 0.01±0.005 | 611±9.00 | 95.97±0.03 | 218±2 |
| F4 | 5.69±0.03 | 130.30±2.03 | 0.02±0.002 | 609±10.00 | 96.89±0.04 | 226±2 |
| F5 | 5.60±0.02 | 120.60±3.04 | 0.03±0.010 | 610±5.00 | 95.46±0.11 | 240±3 |
| F6 | 6.12±0.03 | 50.90±4.30 | 0.08±0.030 | 610±5.00 | 97.96±0.19 | 96±2 |

**Table 5:** Post-coating parameter results

| *Formulation Code* | *Thickness (mm)* | *Hardness (N)* | *Weight variation (mg)* | *Drug content (%)* | *Disintegration time (sec)* |
|---|---|---|---|---|---|
| F6 (Coated) | 6.150±0.02 | 52.39±5.03 | 612±5.00 | 96.49±0.040 | 95±2.51 |

**Table 6:** *In vitro* drug release study of coated tablet

| *Formulation code* | *% CDR at 5 min* | *% CDR at 10 min* | *% CDR at 15 min* | *% CDR at 30 min* |
|---|---|---|---|---|
| F6 (Coated) | 23.64±0.45 | 42.55±0.24 | 71.65±0.11 | 94.64±0.34 |

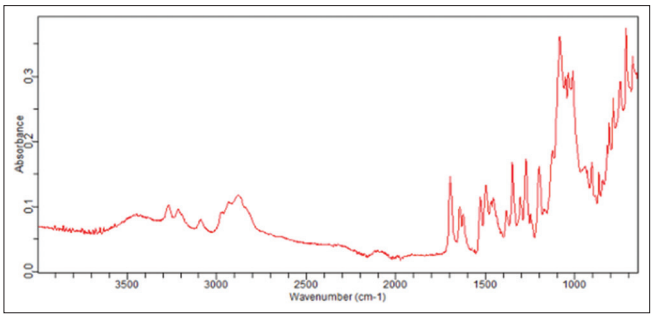


**Figure 11:** FTIR Spectra of Nimodipine + Instacoat Universal

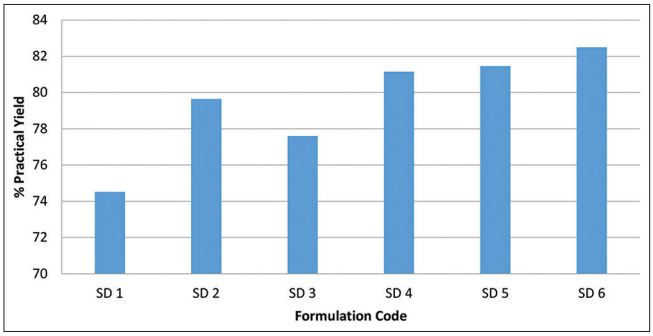


**Figure 12:** % Practical Yield of Nimodipine SD

The HPLC chromatograms of Standard and Sample Nimodipine are represented in below Figure 14 and Figure 15, respectively.

The percentage of cumulative drug release is represented in Figure 16. The drug: Formulations F1, F2, and F3 made without the use of docusate sodium did not confirm the *in vitro* dissolution parameter to that of Pharmacopoeia standard. Only formulations F4, F5, and F6 confirmed the *in vitro* dissolution parameter to

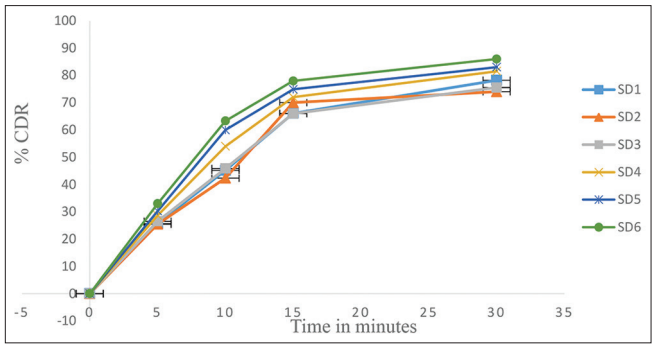


**Figure 13:** % CDR of Nimodipine SD

Pharmacopoeia standard (Not <85%). Among formulations F4, F5, and F6, Formulation F6 with a high surfactant content showed the greatest drug release (101% ± 0.31%). All of these three formulations F4, F5, and F6 contained same drug: PEG 6000 ratio of 1:1 but the surfactant value was different for each formulation and ranged from 0.025% to 0.085%. Thus, the enhanced drug release in formulation F6 is directly related to the role of the surfactant docusate sodium in wetting hydrophobic Nimodipine and thereby enhancing the dissolution properties of the drug.

### *Post-coating studies*

The results for post coating parameters of the optimized batch are shown in Tables 5 and 6.

## Stability Studies

The results of the stability are given in the following Tables 7-9. There was no change in color and shape. There were no significant changes in drug content and %CDR. Three months of stability

**Table 7:** *In vitro* drug release evaluation of accelerated stability study of formulation F6 at 40°C±2°C and 75%±5%RH

| *Time (min)* | *%CDR at initial time* | *%CDR after 1 month* | *%CDR after 2 months* | *%CDR after 3 months* |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 5 | 23.64±0.549 | 28.89±0.125 | 24.95±0.135 | 26.26±0.225 |
| 10 | 42.55±0.334 | 55.48±0.478 | 54.12±0.184 | 54.01±0.423 |
| 15 | 71.65±0.345 | 67.91±0.341 | 71.80±0.367 | 84.94±0.322 |
| 30 | 94.64±0.546 | 93.88±0.233 | 93.99±0.253 | 94.41±0.265 |

**Table 8:** Other evaluation parameters of accelerated stability study of formulation F6 at 40°C±2°C and 75%±5% RH

| *Evaluation parameters* | *At initial time* | *After 1 month* | *After 2 months* | *After 3 months* |
|---|---|---|---|---|
| Color and appearance | No change | No change | No change | No change |
| % drug content | 96.49±0.076 | 95.40±0.175 | 97.00±0.244 | 99.87±0.119 |
| Average Weight (mg) | 612±5.00 | 612.2±3.00 | 611±5.00 | 611.9±4.00 |
| Hardness (N) | 52.39±3.00 | 52.63±5.00 | 52.00±5.00 | 50.85±5.00 |
| DT (sec) | 95±2.00 | 52±3.00 | 50±3.00 | 40±3.00 |

**Table 9:** Evaluation parameters of real-time stability study of formulation F6 at 30°C±2°C and 75%±5%RH

| *Color and appearance* | *%CDR* | | | | | *Average weight (mg)* | *Hardness (n)* | *DT in sec* | *% of drug content* |
|---|---|---|---|---|---|---|---|---|---|
| | *At t=0* | *At t=10* | *At t=15* | *At t=20* | *At t=30* | | | | |
| No change | 0 | 39.27±0.32 | 52.97±0.35 | 81.40±0.49 | 95.16±0.54 | 610.00±8.00 | 40.42±3.00 | 54±2 | 101.09±0.119 |

Here, t=time in minutes

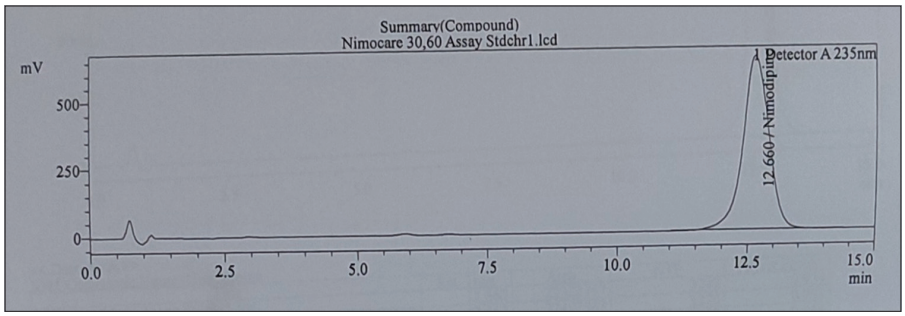


**Figure 14:** HPLC chromatogram of Standard Nimodipine 60

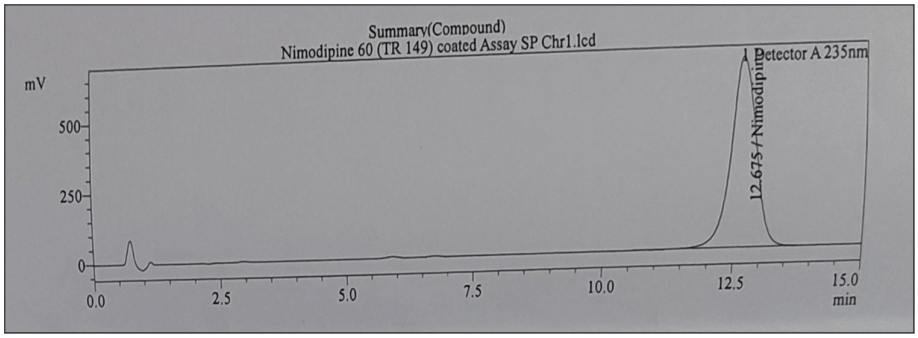


**Figure 15:** HPLC chromatogram of Sample Nimodipine 60

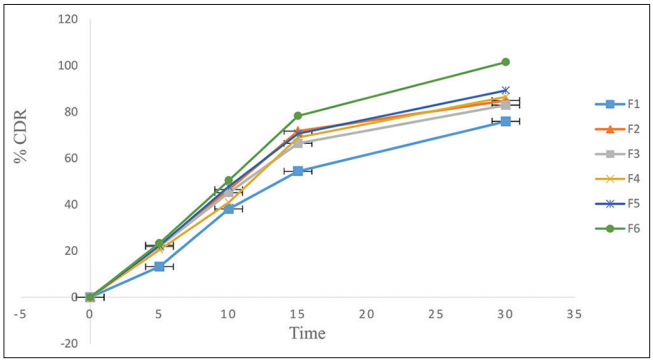


**Figure 16:** *In vitro* drug release study of formulation F1-F6

studies revealed that there was no any significant degradation of the drug.

## Conclusion

From the present work, it can be concluded that immediate release Nimodipine SD tablets were prepared using polymeric carriers such as PEG 6000, PVP K30 and the surfactant sodium docusate by melting, solvent evaporation and melt evaporation SD methods. The formulation prepared by melts evaporation technique using more than one carriers and having high surfactant value showed the increased drug release. The use of docusate sodium had a strong impact on the rate of dissolution. Therefore, SD technique

improved the dissolution rate of poorly water soluble drug Nimodipine, thereby increasing its bioavailability.

## Acknowledgments

The authors thank to Shree Dev Bhoomi Institute of Education Science and Technology for granting all the necessary facilities and Meera Biotech Pvt. Ltd. for providing equipment and materials to complete the research work.

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