ORIGINAL ARTICLE

# Implementing liquisolid compact technique for dissolution rate enhancement of rosuvastatin calcium

**C. Haribabu, S. Subramanian**

*Department of Pharmaceutics, PSG College of Pharmacy, Coimbatore, Tamil Nadu, India*

## Abstract

**Aim:** The main aim of the investigation was to enhance the dissolution rate of rosuvastatin calcium by formulating it as a liquisolid tablet and compare with a marketed formulation. **Materials and Methods:** Rosuvastatin calcium liquisolid tablets were formulated using propylene glycol and PEG 400 as a non-volatile liquid vehicle, Avicel pH 102, and Aerosil 200 as carrier and coating material, sodium starch glycolate as superdisintegrant. The formulated rosuvastatin calcium liquisolid tablet was evaluated for pre-compression parameters to increase the flow property of the drug and post-compression parameters. The *in vitro* drug release characteristics of rosuvastatin calcium liquisolid formulation were performed using pH 6.8 phosphate buffer as dissolution media and compared with the marketed formulation and direct compressible tablet. The analytical study of drug excipient interaction of rosuvastatin calcium was characterized by Fourier transform infrared (FT-IR) and DSC analysis. **Results and Discussion:** The solubility profile of rosuvastatin calcium in propylene glycol and PEG 400 was found to be higher than the other non-volatile liquid vehicle. The formulated rosuvastatin calcium liquisolid tablet (F1, F2, F3, F5, and F6) has accepted flow properties. The post-compression evaluation data of thickness, weight variation, hardness, friability, disintegration, drug content comply with the Indian Pharmacopoeia limits. Among the eight liquisolid formulations (F2) showed the highest percentage of drug release 99% at 60 min, whereas, marketed formulation showed 86.2% of drug release at 60 min. The FT-IR analysis revealed that there is no interaction between drug and excipient. DSC analysis of liquisolid formulation (F2) confirmed the conversion of crystalline state to amorphous form. A significant difference ($P = 0.002 < 0.05$) was found in the dissolution rate of the best formulation (F2) when compared with the marketed formulation. **Conclusion:** It can be concluded from the research work that liquisolid compact technique is a promising method of approach for the dissolution rate enhancement of rosuvastatin calcium due to increased wetting property and more drug surface exposed to the dissolution medium.

**Key words:** Dissolution enhancement, Liquisolid compact, Propylene glycol, Rosuvastatin calcium, Solubility

## INTRODUCTION

Hyperlipidemia is a diseased condition characterized by elevated levels of lipoprotein or cholesterol in the blood.[1] The increased lipoprotein deposition completely blocks the blood supply to the heart resulting in myocardial infarction, also known as a heart attack.[2] Rosuvastatin calcium is a BCS Class II drug with poor solubility and high permeability. It is a class of 3-hydroxy-3-methylglutaryl CoA (HMG-CoA) reductase inhibitor. HMG-CoA reductase enzyme converting HMG-CoA to mevalonate, a significant lipid-lowering agent and hypolipidemic drug which is an early and rate-limiting step in cholesterol production. Rosuvastatin calcium inhibited HMG-CoA reductase more effectively than other statins groups of the drug.[3] The oral route of drug administration is prioritized over other routes because of its convenience, cost, and patient compliance. The oral bioavailability of drugs plays a significant role in the drug dissolution process in the gastrointestinal tract.[4] Due to low aqueous solubility and restricted intestinal permeability, around 40% of newly discovered drug encounters significant biopharmaceutical difficulties, resulting in poor drug absorption and minimal

**Address for correspondence:**
Dr. S. Subramanian, Department of Pharmaceutics, PSG College of Pharmacy, Coimbatore - 641 004, Tamil Nadu, India. Phone: +91-9486220270.
E-mail: subbu3j@gmail.com

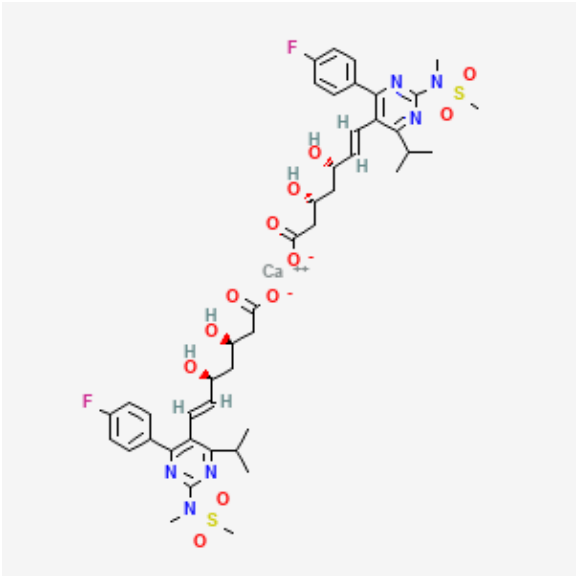
**Received:** 10-09-2021
**Revised:** 20-11-2021
**Accepted:** 28-11-2021

therapeutic benefits.[5] Various methods have been employed to increase the dissolution rate of rosuvastatin calcium which involves SNEDDS,[6] nanoparticles,[7] SEDDS,[8] and niosomes.[9] The liquisolid compact technique aims to improve the dissolution rate of the poorly water-soluble drug belongs to BCS Class II and IV by employing the cosolvency approach which is a low cost-effective technique compared to other methods. Among the various novel techniques for promoting dissolution, the liquisolid formulation is the most unique and new method of approach.[10] Liquisolid systems are powdered type of liquid medications that are well flowing and compressible, immersing the poorly soluble drug in an oily vehicle or solution. The liquid medication can be transformed into a free-flowing and good compressible powder by blending a liquid drug with selected powder excipients known as the carrier and coating material which was added based on the new mathematical model of liquisolid system.[11,12]

## MATERIALS AND METHODS

Rosuvastatin calcium was obtained as a gift sample from Steril-Gene Life Sciences (P) Limited, Puducherry, India. Avicel pH 102 was purchased from Sigma-Aldrich Pvt. Ltd., India. Aerosil 200 was obtained from Otto Chemie Pvt. Ltd., Mumbai, India. Propylene glycol, PEG 400, Tween 80, PEG 200, sodium starch glycolate, magnesium stearate, and talc were purchased from Loba Chemie Pvt. Ltd., Mumbai, India.

### Molecular Structure of Rosuvastatin Calcium[3]



### Determination of Solubility of Rosuvastatin Calcium

The saturation solubility method was performed on the drug rosuvastatin calcium for the selection of the best non-volatile solvents among the liquid's propylene glycol, PEG 400, tween 80, and PEG 200. The solutions were sonicated until an equilibrium state was reached. The samples were centrifuged (Eppendorf 5415 R) at 12,000 rpm for 10 min. After centrifugation, the solutions were filtered through a 0.45 µm membrane filter to separate undissolved drug. The sample solution was diluted and the absorbance was measured at a wavelength of 243 nm, analyzed using an ultraviolet (UV)–visible spectrophotometer (UV- 1650PC, Shimadzu Corporation). Three measurements were made for each sample to calculate the solubility of the drug rosuvastatin calcium.[13]

### Application of Mathematical Model for Design of Liquisolid Systems of Rosuvastatin Calcium

According to the new theories, the non-volatile liquid can only be retained in small amounts by carrier and coating materials to retaining appropriate flow and compression property. The excipient ratio (R) commonly known as the carrier/coating ratio is defined as follows,

$$R=Q/q \quad (1)$$

The excipient ratio (R) is the weight proportion of the carrier (Q) and coating (q) material used in the formulation. To achieve an acceptable flowing and compressible liquisolid system, the liquid load on the carrier material should not be exceeded. Another significant factor to consider is the liquid load factor ($L_f$), which is defined as the weight ratio of the liquid medication (W) and carrier powder (Q) in the system is a characteristics amount of liquisolid system.[12]

$$L_f=W/Q \quad (2)$$

The required amount of carrier and coating material added in the formulation is based on the flowable liquid retention potential (Φ-value) proposed by Spireas *et al*. As a result, the relationship between the powder and excipients ratios [R] and the liquid load factor ($L_f$) of the formulation are as follows,

$$L_f = \Phi + \Phi\,(1/R) \quad (3)$$

Where, Φ and Φ indicate flowable liquid retention potential value of carrier and coating material. Hence, to determine the required weight of the carrier and coating material employed first using the Equation (3), $L_f$ was derived from the linear relationship of $L_f$vs1/R based on the carrier/coating material ratio (R), following that different weight of the liquid drug, the solution will be employed depending on the liquid vehicle concentration. Hence, if both $L_f$and W are known, the required quantities of the carrier (Q) and coating (q) materials needed to convert a given amount of liquid medication (W) into a flowable and compressible liquisolid system can be determined using Equations (1) and (2).[12]

### Preparation of Rosuvastatin Calcium Liquisolid Tablet and Direct Compressible Tablet (DCT)

Rosuvastatin calcium DCT shown in Table 1 was prepared using a Minipress tablet punching machine (RIMEK, Ahmedabad, India).[14]

Each liquisolid compact formulation denoted F1–F8 as shown in Table 2 containing 10 mg of accurately weighed rosuvastatin calcium and 100 mg (10%) of propylene glycol and PEG 400.[13] Each liquefied mixture was exposed to heat at 50°C with continuous stirring until a homogenous mixture was achieved. The addition of carrier material into the admixture of drug and vehicle is triturated well using mortar and pestle and waited for 10 min for complete absorption of the liquefied drug in the porous carrier material. Then, coating material was added in a weighed amount and triturated gently for 15 min to ensure complete adsorption of the coating substance over the porous carrier material. At last, coprocessed 5% sodium starch glycolate as a superdisintegrant, 2% magnesium stearate as a lubricant, and 1% talc as glidant were added to the above powder blend mixture and mixed all thoroughly. The final powder blend mixture was compressed on 6 mm and 9 mm punch and die using a Minipress tablet machine (RIMEK, Ahmedabad, India).[15]

### Evaluation of Liquisolid Compact Formulations

#### *Pre-compression evaluation of rosuvastatin calcium liquisolid powder systems*

The flow characteristics of the liquisolid blends were evaluated by determining the properties such as angle of repose, Carr's index, and Hausner's ratio. The angle of repose of powder blend is calculated using the fixed funnel method.[16] The bulk density was determined by placing a specific amount of powder in a graduated cylinder and the volume obtained was measured and the bulk density was determined.[17] Then, the graduated cylinder was exposed to several taps until the constant volume was obtained and the tapped density was determined.[17] The percentage compressibility of a powder is a direct measure of the potential of powder arch or bridge strength and compressibility index was determined.[15] Hausner's ratio is a number that relates to a powder or granule material's flowability. From the obtained value of bulk density and tapped density, the value of compressibility index and Hausner's ratio was determined.[16]

### Fourier-Transform Infrared (FT-IR) Spectroscopy Analysis

The FT-IR spectrum of rosuvastatin calcium and excipients used in liquisolid formulations were studied to confirm the free of interaction between drug and excipients by preparing in potassium bromide pellet technique using FT-IR spectrophotometer (FT-IR 8400 Shimadzu 240V, Shimadzu Corporation).[18]

### Differential Scanning Calorimetry (DSC) Analysis

DSC study was used to analyze the thermotropic characteristics and thermal behavior of pure rosuvastatin calcium, and liquisolid compact formulation using a DSC3 Mettler-Toledo GmbH, Switzerland, at a heating rate of 10°C–340°C/min using samples load of 8 mg contained in aluminum pan and sealed.[19]

**Table 1:** Formulation table of rosuvastatin calcium DCTs

| Formulation | Drug (mg) | Avicel (Q) (mg) | Aerosil (q) (mg) | SSG (mg) | Magnesium stearate (mg) | Talc (mg) | Total weight (mg) |
|---|---|---|---|---|---|---|---|
| DCT | 10 | 150 | 15 | 8.75 | 3.5 | 1.75 | 189 |

DCT: Direct compressible tablet

**Table 2:** Formulation table of rosuvastatin calcium liquisolid compacts

| Formulation | Drug (mg) | Drug conc. in PG (%w/w) | Drug conc. in PEG 400 (%w/w) | R | Lf | Avicel (Q) (mg) | Aerosil (q) (mg) | SSG 5% (mg) | Tablet weight (mg) |
|---|---|---|---|---|---|---|---|---|---|
| F1 | 10 | 10% | | 5 | 0.822 | 121.6 | 24.3 | 12.8 | 276 |
| F2 | 10 | 10% | - | 10 | 0.491 | 203.6 | 20.36 | 16.7 | 360 |
| F3 | 10 | 10% | | 15 | 0.380 | 263.1 | 17.54 | 19.5 | 422 |
| F4 | 10 | 10% | | 20 | 0.325 | 307.6 | 15.38 | 21.6 | 467 |
| F5 | 10 | - | 10% | 5 | 0.657 | 152.2 | 30.44 | 14.6 | 316 |
| F6 | 10 | | 10% | 10 | 0.331 | 302.1 | 30.21 | 22.1 | 477 |
| F7 | 10 | | 10% | 15 | 0.222 | 450.45 | 30.03 | 29.5 | 637 |
| F8 | 10 | | 10% | 20 | 0.168 | 595.23 | 29.76 | 36.7 | 793 |

Each formulation containing 10 mg of rosuvastatin calcium, magnesium stearate – 2%, and talc – 1%. PG: Propylene glycol, R: Carrier and coating material ratio, Lf: Liquid load factor, Q=W/Lf (Q: Carrier material and W: Total weight of liquid medication)

### Post-compression Evaluation of Rosuvastatin Calcium Liquisolid Tablets

#### *Thickness*

Vernier caliper was used to measure the thickness of the tablet.[17]

#### *Weight variation test*

The test was carried out according to the Indian Pharmacopoeia, which included weighing 20 tablets of rosuvastatin calcium individually using an electronic balance (AY220, Shimadzu Corporation, Japan). To determine the percentage (%) deviation of individual tablet by comparing it with average value of 20 tablets of Rosuvastatin Calcium.[11]

### Hardness

The hardness of the tablet was determined using a hardness tester (ERWEKA TBH 125, Erweka India Pvt. Ltd., Mumbai). Randomly chosen tablets from each formulation were placed on the anvil of the tablet hardness tester. On the screen of the hardness tester, the reading in Newton (9.807 Newton = 1 kg) at the breakage point of the tablet was shown.[19]

### Friability

The friability of tablets was evaluated using a friability tester (INWEKA, India Pvt. Ltd., Mumbai). Twenty tablets were randomly chosen and weighed before being placed in the rotating drum. The initial weight of the tablet was noted down. The drum was rotated at 25 rpm for up to 4 min. After complete rotations, the tablet was taken, and the tablet was weighed again to determine the % friability.[14]

### Disintegration Time

The disintegration test of liquisolid tablet was performed according to Indian Pharmacopoeia 1996. The USP disintegration apparatus (LABINDIA DT 1000, Lab India Analytical Pvt. Ltd., Mumbai) was used to conduct the disintegration test. Six tablets from each formulation were randomly chosen and placed in a disintegration apparatus. The time taken for the tablet to completely disintegrate was recorded.[20]

### Content Uniformity Test

The tablet content uniformity test was carried out using 20 tablets in accordance with Indian Pharmacopoeia. The powder blend equivalent to 10 mg of rosuvastatin calcium was accurately weighed and dissolved in 10 ml of methanol and shaken for 10 min. Then, the volume was made up to 100 ml in a volumetric flask with pH 6.8 phosphate buffer. The sample solution was filtered through a 0.45 µm membrane and the absorbance of the resultant solution was analyzed using a UV–visible spectrophotometer (UV-1650PC, Shimadzu Corporation) at 243 nm, respectively.[17]

### *In vitro* Dissolution Studies

The drug release rate of rosuvastatin calcium was examined using USP type II (paddle) dissolution apparatus (LABINDIA DS8000, Lab India Analytical Pvt. Ltd., Mumbai). The drug release study was used to compare between rosuvastatin calcium liquisolid tablet, DCT, and marketed tablet. The tablet was kept in the USP type II paddle dissolution apparatus and the dissolution medium was maintained at a rotating speed of 50 rpm in the volume of 900 ml of pH 6.8 phosphate buffer at a temperature of 37°C ± 0.5°C. Five milliliters samples were withdrawn from the medium at a particular time interval (15, 20, 30, 45, and 60 min) and replaced with an equal amount of pH 6.8 phosphate buffer solution to maintain the dissolution medium. The withdrawn samples were filtered by passing through a 0.45 µm membrane and the absorbance of the filtered sample solution was analyzed at 243 nm using a UV–visible spectrophotometer (UV-1650PC, Shimadzu Corporation).[21]

### *In vitro* Drug Release Kinetics

*In vitro* drug release data of liquisolid formulations (F2) were fitted to various drug release kinetic models using DD solver software to identify the drug release kinetics model for the formulation (F2). From the inference of Korsmeyer–Peppas "*n*-value," the drug release mechanism can be identified for the liquisolid formulation (F2).[22]

### Statistical Analysis

The statistical analysis for dissolution studies was carried out using Student's *t*-test (GraphPad Prism Software Version 9.0) at a level of $P = 0.05$.

## RESULTS AND DISCUSSION

### Solubility Studies Profile of Rosuvastatin Calcium

The solubility study of rosuvastatin calcium was determined in different non-volatile solvents shown in Figure 1. More drug solubility in non-volatile liquid vehicles facilitates molecular dispersion, increased wettability, and more surface of the drug exposed to the dissolution medium resulting in enhanced dissolution rate. Based on the solubility studies of rosuvastatin calcium, propylene glycol and PEG 400 were selected as the non-volatile liquid used for the formulation of liquisolid tablets.[17]

### Calculation of Flowable Liquid Retention Potential (Θ-Value) and Liquid Load Factor ($L_f$)

The Φ-value of the carrier (Avicel pH 102) and coating (Aerosil 200) materials in propylene glycol was found to be 0.16 and 3.31 and in PEG 400 was found to be 0.005 and 3.26.[23] These values are shown in the literature proposed by Spireas *et al*., based on the above Φ-values and using different ratios (R-value), the amount of carrier and coating materials, and liquid load factor ($L_f$) can be calculated. The following Equations (1 and 2) are followed for the calculation of Φ-values and liquid $L_f$ of propylene glycol (1) and PEG 400 (2). Based on the different ratios (R) of carrier and coating materials, liquid load factor may differ.[4,12]

$$L_f = 0.16 + 3.31\ (1/R) \quad (1)$$

$$L_f = 0.005 + 3.26\ (1/R) \quad (2)$$

### Pre-Compression Parameter Evaluation

From the obtained results of the angle of repose shown in Table 3, it is revealed that the decrease in the ratio of carrier and coating material in the formulations (F1, F2, F3, F5, and F6) exhibits good flow properties and it complies with the Indian Pharmacopoeia limits.[13] Based on the obtained value of bulk density and tapped density mentioned in Table 3, the value of Carr's index and Hausner's ratio can be calculated. From the obtained results shown in Table 3, formulations (F1, F2, F3, F5, and F6) achieves good flow behavior shows value within the range of 11.15 ± 0.35–14.93 ± 0.51 for Carr's index and 1.12 ± 0.04–1.17 ± 0.07 for Hausner's ratio.[13]

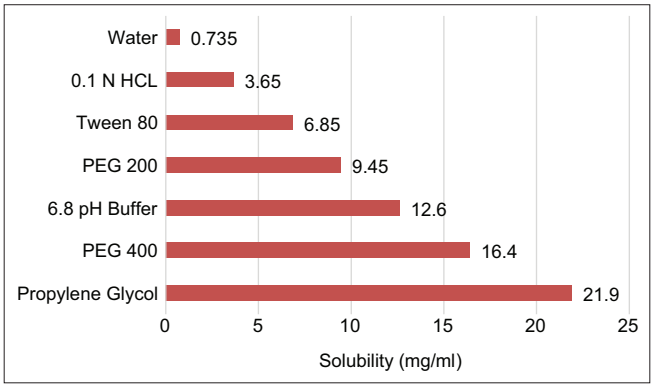



**Figure 1:** Solubility data of Rosuvastatin Calcium in various non-volatile solvents

### FT-IR Analysis

The FT-IR spectrum of pure rosuvastatin calcium and liquisolid formulation was determined. Between drug and excipients, there was no significant alteration in the position of the peak in a physical mixture, from this phenomenon, it is revealed that there is no interaction between drug and excipients.[19,24]

### DSC Analysis

The DSC thermogram of pure rosuvastatin calcium in Figure 2 shown a sharp endothermic peak at 82.84°C related to its melting point. The presence of such a sharp endothermic peak indicates the rosuvastatin calcium in crystalline form. There was no additional peak seen on the thermogram of liquisolid formulation (F2) shown in Figure 3 which indicates the absence of interaction between drug and excipients. The complete absence of endothermic peak of pure rosuvastatin calcium in liquisolid formulation reveals that the drug molecule was completely dispersed within the liquisolid system. The complete absence of the drug endothermic peak implies that the drug state changes from crystalline to amorphous form completely.[19]

### Post-Compression Parameter Evaluation

The thickness of all rosuvastatin calcium tablet shown in Table 4 was found in the range of 3.22 ± 0.04 mm–5.58 ± 0.04 mm. The weight variation in the tablet will affect the amount of drug present in the tablet, a weight variation

**Table 3:** Flow properties of rosuvastatin calcium liquisolid powder and DCT

| Formulations | Bulk density (g/ml) | Tapped density (g/ml) | Angle of repose (Θ) | Hausner's ratio | Carr's index (%) |
|---|---|---|---|---|---|
| F1 | 0.445±0.03 | 0.511±0.02 | 33.14±0.81 | 1.14±0.03 | 12.91±0.25 |
| F2 | 0.450±0.06 | 0.529±0.04 | 30.24±0.28 | 1.17±0.07 | 14.93±0.51 |
| F3 | 0.479±0.02 | 0.541±0.07 | 32.82±0.32 | 1.12±0.05 | 11.46±0.44 |
| F4 | 0.457±0.04 | 0.555±0.04 | 36.90±0.29 | 1.21±0.06 | 17.65±0.23 |
| F5 | 0.438±0.03 | 0.493±0.06 | 33.42±0.67 | 1.12±0.04 | 11.15±0.35 |
| F6 | 0.441±0.04 | 0.507±0.03 | 31.21±0.36 | 1.14±0.03 | 13.01±0.27 |
| F7 | 0.468±0.07 | 0.558±0.05 | 36.20±0.54 | 1.19±0.04 | 16.12±0.47 |
| F8 | 0.440±0.05 | 0.528±0.03 | 37.23±0.91 | 1.20±0.05 | 16.66±0.62 |
| DCT | 0.410±0.05 | 0.472±0.06 | 32.53±0.23 | 1.15±0.02 | 13.13±0.37 |

(mean±SD, *n*=3)

test was done with 20 tablets from each formulation. The weight variation results reported in Table 4, which reveal that the individual tablet weight is within the range of around ±5% deviation for F1–F7 formulation (as per Indian Pharmacopoeia limits) from the average weight of the tablet. The hardness of the liquisolid tablet determines

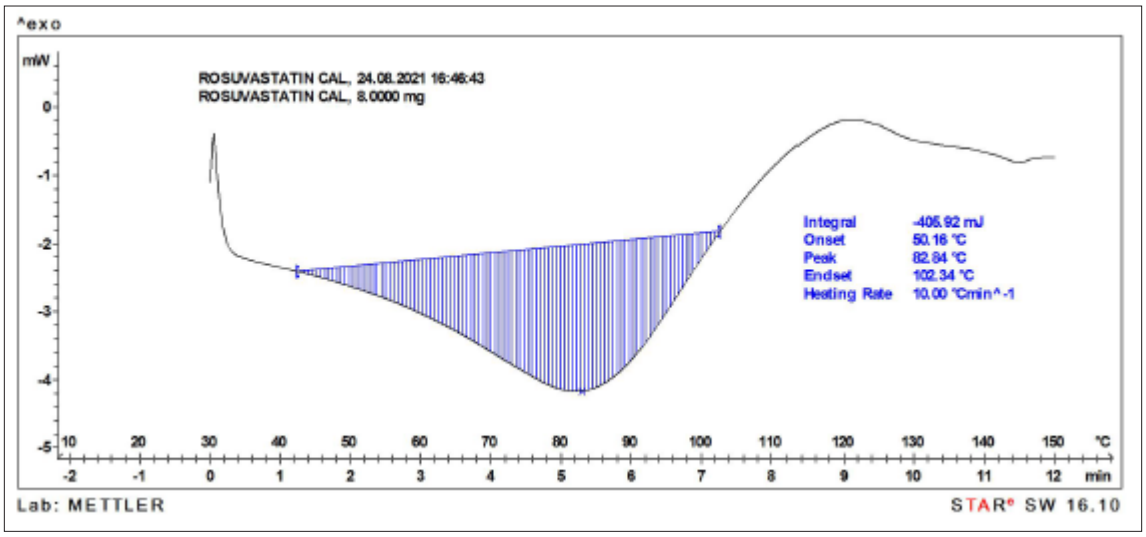



**Figure 2:** DSC thermogram of pure drug rosuvastatin calcium

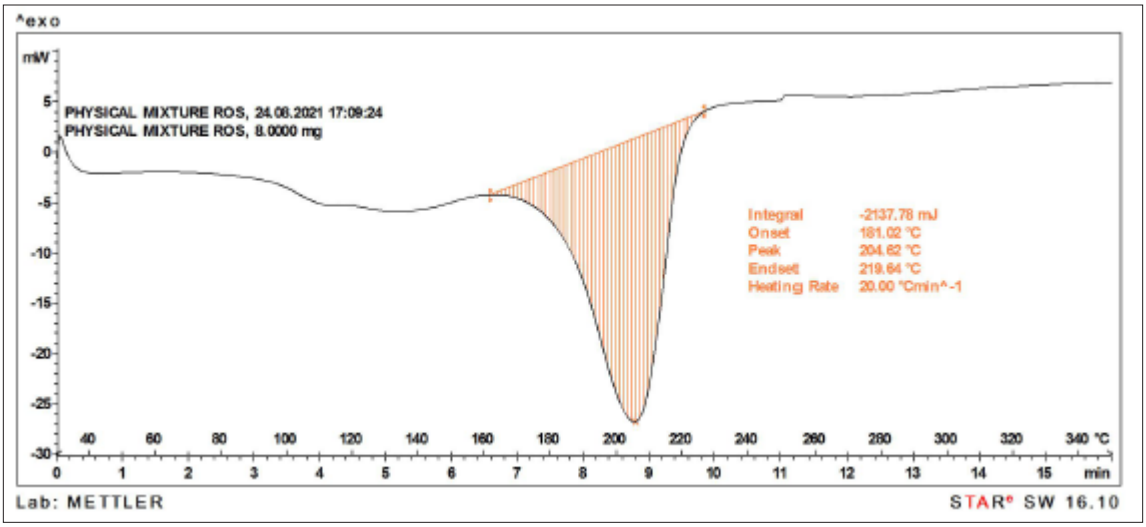



**Figure 3:** DSC thermogram of liquisolid formulation (F2)

**Table 4:** Post-compression evaluation of rosuvastatin calcium liquisolid tablet and DCT

| Formulations | Thickness (mm) | Hardness (Newton) | Weight variation (mg) | Friability (%) | Disintegration time (min) | Drug content (%) |
|---|---|---|---|---|---|---|
| F1 | 3.58±0.06 | 43±1 | 275.85±0.56 | 0.225±0.02 | 6.52±0.50 | 98.1±0.44 |
| F2 | 4.16±0.05 | 43±1 | 359.66±0.74 | 0.285±0.05 | 7.33±0.27 | 99.8±0.57 |
| F3 | 4.61±0.26 | 46±2 | 420.69±1.02 | 0.445±0.07 | 8.06±0.34 | 96.4±0.38 |
| F4 | 4.90±0.02 | 50±1 | 467.31±0.97 | 0.255±0.04 | 8.32±0.49 | 97.5±1.20 |
| F5 | 4.28±0.06 | 40±2 | 315.73±1.19 | 0.489±0.05 | 6.35±0.34 | 98.7±0.28 |
| F6 | 4.97±0.07 | 48±1 | 476.80±0.52 | 0.356±0.06 | 7.53±0.31 | 99.3±0.64 |
| F7 | 5.25±0.03 | 52±2 | 637.19±1.11 | 0.212±0.03 | 8.54±0.42 | 96.9±0.46 |
| F8 | 5.58±0.04 | 57±1 | 792.87±0.47 | 0.297±0.04 | 9.12±1.05 | 95.8±0.75 |
| DCT | 3.22±0.04 | 41±1 | 188.79±0.80 | 0.441±0.03 | 6.13±0.42 | 94.6±0.52 |

(mean±SD, *n*=3)

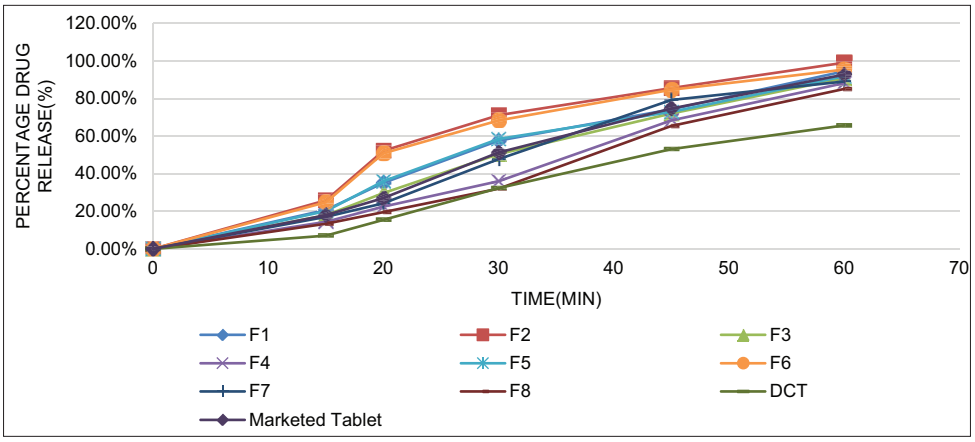



**Figure 4:** Comparative dissolution profile of rosuvastatin calcium liquisolid formulations (F1–F8), marketed formulation, and DCT

its resistance to abrasion or breaking during handling, packaging, and transportation. The hardness of the tablet from each formulation shows the acceptable limit reported in Table 4 to comply with Indian Pharmacopoeia limits. From the obtained results, it is revealed that with the increase in R-value, the hardness was found to be increased. The friability range of formulated liquisolid tablet is shown in Table 4, and the percentage friability did not exceed 1% of the tablet weight for all the formulations. Thus, none of the tablets were cracked or broken during the friability test. The disintegration time of all the liquisolid tablets reported in Table 4 disintegrates between 6.35± 0.34 min and 9.12 ± 1.05 min (≤15 min), it states that all liquisolid tablets pass the disintegration test. From the results, it revealed that the ratio (R) of carrier and coating material delayed the disintegration time of the liquisolid tablet. The drug content for all the liquisolid tablet formulations ranges from 95.8 ± 0.75% to 99.8 ± 0.57%, as shown in Table 4. From the obtained results, it states that drug content was uniform for all the formulations and it complies with Indian Pharmacopoeia limits of 85–115%.

### *In vitro* Dissolution Study

*In vitro* drug release study was performed for all liquisolid formulations and it is compared with the marketed formulation and DCT. The percentage drug release profile comparison is shown in Figure 4. Based on the drug release data, liquisolid formulation (F2) contained the drug concentration of 10% in propylene glycol and 10:1 ratio of the carrier: coating shows the highest percentage of drug release of 99% at 60 min compared with DCT showed 65.7% and marketed formulation showed 86.2% at 60 min, respectively. The dissolution rate is influenced by the drug concentration and solubility in the non-volatile liquid vehicle. Hence, when a drug is solubilized more in a liquid vehicle and due to the increased wetting property, its dissolution rate gets enhanced. Hence, propylene glycol containing liquisolid formulation (F2) showed more drug release than the marketed formulation.

### *In vitro* Drug Release Kinetics

The drug release kinetics of liquisolid formulation (F2) was subjected to various drug release kinetic models. As a kinetic model of the drug release pattern, the model with the greatest correlation coefficient ($r^2$), that is, close to 1 was chosen. According to the ($r^2$) value, the drug release data of best formulation (F2) fitted well to the Weibull model ($r^2 = 0.9879$) and it follows the non-Fickian transport diffusion and erosion mechanism is shown by the exponent value ($n$ = 0.714) generate from the Korsmeyer–Peppas model. Thus, drug release is controlled by both diffusion controlled and swelling controlled release.

## CONCLUSION

From the experimental results, to enhance the dissolution rate of rosuvastatin calcium, liquisolid compact was selected as one of the promising techniques available. Among the liquisolid formulations (F2) containing 10% concentration of Rosuvastatin Calcium in propylene glycol shown 99% of drug release at 60 mins when compared to marketed formulation shown 86.2% of drug release at 60 mins. The non-volatile liquid vehicle plays a significant role in dissolution enhancement by the properties of increased wetting and more drug surface exposed to the dissolution medium. The FT-IR spectrum analysis revealed that no interactions occurred between drug and excipients. The DSC analysis confirmed that the drug rosuvastatin calcium changes its state from crystalline to amorphous. Thus, the liquisolid compact technique proved to be an emerging technique for dissolution rate enhancement of poorly aqueous-soluble rosuvastatin calcium.

## ACKNOWLEDGMENT

The authors would like to thank PSG College of Pharmacy for providing all the required facilities for performing this work.

## REFERENCES


1. Verma N. Introductiontohyperlipidemiaand its treatment. Int J Curr Pharm Res 2017;9:6-14.
2. Shattat GF. A review article on hyperlipidemia: Types, treatments and new drug targets. Biomed Pharmacol J 2015;7:399-409.
3. Quirk J, Thornton M, Kirkpatrick P. Rosuvastatin calcium. Nat Rev Drug Discov 2003;2:769-70.
4. Pawar JD, Jagtap RS, Doijad RC, Pol SV, Desai JR, Jadhav VV, *et al*. Liquisolid compacts: A promising approach for solubility enhancement. J Drug Deliv Ther 2017;7:6-11.
5. Bonthagarala B, Dasari V, Kotra V, Swain S, Beg S. Quality-by-design based development and characterization of pioglitazone loaded liquisolid compact tablets with improved biopharmaceutical attributes. J Drug Deliv Sci Technol 2019;5:345-55.
6. Beg S, Katare OP, Singh B. Formulation by design approach for development of ultrafine self-nanoemulsifying systems of rosuvastatin calcium containing long-chain lipophiles for hyperlipidemia management. Colloids Surf B Biointerfaces 2017;159:869-79.
7. Ponnuraj R, Janakiraman K, Gopalakrishnan S, Jeyakumar HJ, Venkateswarlu V, Narayanan DS. Formulation and characterization of rosuvastatin calcium nanoparticles. Indo Am J Pharm Res 2015;5:767-79.
8. Karasulu HY, Gündoğdu E, Turgay T, Türk UÖ, Apaydın S, Şimşir IY, *et al*. Development and optimization of self-emulsifying drug delivery systems (SEDDS) for enhanced dissolution and permeability of rosuvastatin. Curr Drug Deliv 2016;13:362-70.
9. Liu Q, Xu J, Liao K, Tang N. Oral bioavailability improvement of tailored rosuvastatin loaded niosomal nanocarriers to manage ischemic heart disease: Optimization, *ex vivo* and *in vivo* studies. AAPS Pharm Sci Tech 2021;22:1-9.
10. Gorle AP. Chopade SS. Liquisolid technology: Preparation, characterization and applications. J Drug Deliv Ther 2020;10:295-307.
11. Magdum SS. Liquisolid technique for dissolution and bioavailability enhancement of poorly soluble drugs. Univers J Pharm Res 2017;2:46-53.
12. Spireas S, Sadu S. Enhancement of prednisolone dissolution properties using liquisolid compacts. Int J Pharm 1998;166:177-88.
13. Devarshi HS, Madhabhai MP. Formulation and evaluation of liquisolid compacts of olanzapine. J Drug Deliv Ther 2019;9:189-202.
14. Jassim EZ. Formulation and evaluation of furosemide liquisolid compact. Int J Appl Pharm 2017;9:39-48.
15. Bharathi A, Sailaja CS, Naik DC. Enhancement of solubility of simvastatin by using liquisolid compact technique. Int Res J Pharm 2019;10:141-6.
16. Kumar PV, Rajalakshmi AN, Stephen P. Formulation and evaluation of orodispersible liquisolid compacts of nifedipine using co-processed superdisintegrants. Asian J Pharm Pharmacol 2018;4:505-13.
17. Monali K, Ashok B, Ravindra P, Sujit K. Formulation and evaluation of telmisartan liquisolid compact tablets. IJPPR Human 2017;9:152-82.
18. Egla M, Abd SN, Hammid AL. Design zolmitriptan liquisolid orodispersible tablets and their *in vitro* evaluation. Int J Pharm Pharm Sci 2017;9:297-303.
19. Atiya KK, Ibraheem JJ, Ghareeb MM. Liquisolid compact as an approach for tenoxicam solubility enhancement using tween 80 as liquid vehicle. J Chem Pharm Res 2015;7:379-93.
20. Dias RJ, Mali KK, Ghorpade VS, Havaldar VD, Mohite VR. Formulation and evaluation of carbamazepine liquisolid compacts using novel carriers. Indian J Pharm Educ Res 2017;51:69-78.
21. Sarfraz RM, Ahmad M, Mahmood A, Minhas MU, Yaqoob A. Development and evaluation of rosuvastatin calcium based microparticles for solubility enhancement. Adv Polym Technol 2017;36:1-9.
22. Saeedi M, Akbari J, Semnani K, Hashemi SM, Ghasemi S, Tahmasbi N, *et al*. Controlling atorvastatin release from liquisolid systems. J Dispers Sci Technol 2020;42:1-10.
23. Spireas S. Liquisolid Systems and Methods of Preparing Same, U. S. Patent No. 5968550; 1999.
24. Suryawanshi VK, Gidwani B, Verma A, Dubey N, Kaur CD. Formulation and evaluation of ramipril liquisolid compact using novel carriers. IJPSR 2019;10:917-25.


**Source of Support:** Nil. **Conflicts of Interest:** None declared.