STM JOURNALS

Research & Reviews: A Journal of
Pharmaceutical Science

ISSN: 2229-7006
Volume 17, Issue 1, 2026
January–April
DOI (Journal): 10.37591/RRJoPS

https://journals.stmjournals.com/rrjops

Research RRJOPS

Solubility Enhancement Technique for Verapamil by Solid Dispersion Method

Ashwini Jadhav[1,*], Prajwal Cheulkar[2], Harsh Gore[2], Prasad Magare[2], Neha Gupta[1], Kiran Bhosale[1], Tushar Shelke[3]

Abstract

By creating a solid dispersion, this study aimed to address the limitations of the traditional solid dosage form of verapamil, including its low bioavailability and restricted clinical efficacy. In order to alter the drug's release and improve its solubility, verapamil solid dispersion was created using the Solvent Evaporation Method and Fusion Method. The physical state of the solid dispersed verapamil was determined using saturation solubility testing and dissolution studies. Verapamil Solid Dispersions Prepared using the Fusion Method (Drug to PEG-4000:1:2) results in maximum drug release as compared to pure drug, and the dissolution of verapamil solid dispersion is significantly improved. The current study showed that the employment of water-soluble carriers in a variety of solid dispersion techniques increased the solubility of weakly water-soluble medicines significantly.

Keywords: Solubility, Bioavailability, Solid Dispersion, Dissolution, Solvent Evaporation

INTRODUCTION

The oral route of medicine administration is the most widely used and advised delivery method since it is easy to use and convenient [1, 2]. For many medications, oral administration may be a poor delivery technique for a variety of reasons, even though it is the preferred option. Among the possible issues that may arise when administering an active agent orally, limited medication absorption leading to poor bioavailability is crucial [3–5]. There are numerous factors that can restrict drug absorption from the gastrointestinal (GI) tract, but the two most significant are the drug molecule's low water solubility and/or membrane permeability. An active substance must first dissolve in stomach and/or intestinal fluids before it can cross the GI tract's membranes and enter the systemic circulation.

As a result, a therapy with low water solubility would often have dissolution rate limited absorption, whereas a drug with low membrane permeability will usually have permeation rate limited absorption [6–9]. As a result, one of the two primary goals of pharmaceutical research is to improve the rate of dissolution and solubility of medications that are not highly soluble in water, as well as to increase the oral bioavailability of active compounds. (ii) enhancing the permeability of poorly permeable pharmaceuticals. Therefore, by enhancing the dissolving qualities of drugs that are weakly water soluble, solid dispersion technologies are used to increase their oral bioavailability [10]. Verapamil is a member of the calcium-channel blocker drug class. It works well to suppress arrhythmias as an antiarrhythmic medication. Myocardial infarction and cardiomyopathy are supported by its potent vasodilation and adverse inotropic effects [11–13].

By reducing the muscles of the heart and blood arteries, it lessens the effort needed for the heart to

***Author for Correspondence**
Ashwini Jadhav
E-mail: avj.gsmcop@gmail.com

[1]Assistant Professor, Genba Sopanrao Moze College of Pharmacy, Wagholi Pune, Maharashtra, India.
[2]Research Scholar, Genba Sopanrao Moze College of Pharmacy, Wagholi Pune, Maharashtra, India.
[3]Principal, Genba Sopanrao Moze College of Pharmacy, Wagholi Pune, Maharashtra, India.

Received Date: September 30, 2025
Accepted Date: November 23, 2025
Published Date: November 27, 2025

Citation: Ashwini Jadhav. Prajwal Cheulkar, Harsh Gore, Prasad Magare, Neha Gupta, Kiran Bhosale, Tushar Shelke. Solubility Enhancement Technique for Verapamil by Solid Dispersion Method. Research & Reviews: A Journal of Pharmaceutical Science. 2026; 17(1): 94–99p.

pump blood. Verapamil also enhances blood and oxygen flow in the heart while decreasing electrical activity in the heart, which helps moderate heart rate. Verapamil is used to treat angina (chest pain), high blood pressure, and certain heart rhythm disorders. Adults and children with particular cardiac rhythm problems can use verapamil injections to swiftly or temporarily restore their heart rhythms to normal [14].

MATERIAL AND METHODS

Verapamil was obtained as a gift sample from Emcure Pharmaceuticals in Pune. Cholesterol and soy lecithin were acquired from Thermosil Fine Chem Pvt Ltd., Pune. The best and purest quality reagents and analytical-grade solvents were utilized, and all solutions were made with deionized distilled water.

Pharmaceutical Buffer Preparations

- *N Hydrochloric acid:* 100 ml of purified water was used to dissolve 0.85 ml of concentrated hydrochloric acid.
- *Phosphate buffer pH 6.8:* Distilled water was used to dilute 100 ml of 0.1 M potassium dihydrogen phosphate and 44.8 ml of 0.1 M sodium hydroxide to 200 ml.

Preformulation Studies

Construction of Standard Calibration Curve for Verapamil HCl

Preparation of Standard Calibration Curve of Verapamil in 0.1N HCL

- *Preparation of standard solution:* A little amount of 0.1 N HCl was used to dissolve 100 mg of verapamil HCl, which had been precisely weighed into a 100 ml volumetric flask. Using 0.1 N HCl, the volume was adjusted to achieve a concentration of 1000µg/ml (SS-I). 10µg/ml (SS-II) was obtained by extracting 1 ml and diluting it with 100 ml.

Preparation of Standard Calibration Curve of Verapamil in PH 6.8

- *Preparation of Working Standard Solutions:* 1 ml, 2 ml, 3 ml, 4 ml, and 5 ml aliquots of (SS-II) were pipetted into 10 ml volumetric flasks. The final concentrations were 1, 2, 3, 4, and 5 µg/ml, with 0.1N HCl as the volume. The UV spectrum of verapamil HCl in 0.1N HCl had a λmax of 278 nm, as measured between 200 and 400 nm. At 278 nm, absorbance was measured with a UV-Visible Spectrophotometer (UV-1800 SHIMADZU) and 0.1N HCl as a blank. Creating a standard calibration curve for verapamil HCl with a pH of 6.8.

Solubility Studies

- *Solubility of Verapamil HCl:* Verapamil HCl's solubility in several solvents was assessed. For 48 hours at room temperature, excess verapamil HCl (also known as saturated solubility) was dissolved and agitated in several solvents. The solutions should be filtered, the filtered supernatants precisely weighed, and the filtrate diluted for subsequent examination using spectrophotometry at 278 nm. Verapamil HCl's solubility in the appropriate liquid vehicle was computed using the data that was obtained [15].

PREPARATION OF VERAPAMIL SOLID DISPERSIONS

Solvent Evaporation Method

The ratios of verapamil and PEG-6000 were 1:1 and 1:2, respectively, while the ratios of verapamil and ß-cyclodextrin were also 1:1 and 1:2. The mixture was dissolved in 5 milliliters of methanol in a China dish. Two grams of the carrier were added to the methanol solution, and the mixture was left to evaporate at room temperature for a full day. After that, the mixture was collected, carefully packed, and put into glass containers with an amber hue. The solid dispersions of verapamil were stored at room temperature. The compositions of the several solid dispersions of verapamil are shown in Table 1 [16].

Table 1. Formulation of solid dispersion by solvent evaporation method.

S.N.	Composition	Ratio
1	VERAPAMIL + PEG-6000	1: 1
2	VERAPAMIL + PEG-6000	1: 2
3	VERAPAMIL+ ß-cyclodextrin	1: 1
4	VERAPAMIL+ ß-cyclodextrin	1: 2

Fusion Method

Preparation of Physical Mixture and Solid Dispersion

With mixing procedure, physical mixtures (PMs) of verapamil were created utilizing two distinct carriers, PEG 4000 and HPMC, in various ratios of 1:1 w/w and 1:2 w/w, respectively. Each carrier was taken separately and heated to a molten state at 60°C in order to prepare the solid dispersion (SD). Then, the weighed amount of Verapamil was added to the molten carrier with continuous stirring using a glass rod until dissolved. Two different solid dispersions (SD) were obtained, one using PEG 4000 &HPMC as the carrier and both in a 1:1w/w,1:2 w/w ratio of Verapamil to the respective carrier. The mixtures were allowed to solidify at room temperature. After a whole day in a desiccator, the final pieces were pounded with a porcelain mortar and pestle. To provide a constant particle size distribution, the ground powder was passed through an 80-mesh screen. Table 2 outlines the various Verapamil solid dispersions' constituents [17].

Table 2. Formulation of solid dispersion by fusion method.

S.N.	Composition	Ratio
1	VERAPAMIL + PEG-4000	1: 1
2	VERAPAMIL + PEG-4000	1: 2
3	VERAPAMIL+ HPMC	1: 1
4	VERAPAMIL+ HPMC	1: 2

EVALUATION TEST

Solubility of Solid Dispersion of Verapamil by Solvent Evaporation Method and Fusion Method

Verapamil's solid dispersion's solubility in several solvents was assessed. Verapamil's excess solid dispersion was dissolved and agitated for 48 hours at room temperature in several solvents. The solutions should be filtered, the filtered supernatants precisely weighed, and the filtrate diluted for subsequent examination using spectrophotometry at 278 nm. Verapamil's solubility solid dispersion in the corresponding liquid vehicle was computed using the data that was acquired [18].

In Vitro Dissolution Testing of Solid Dispersion of Verapamil by Solvent Evaporation Method and Fusion Method

Solubility enhanced dispersions were dissolved in a calibrated eight-station dissolving test equipment with paddles in 900 ml of clean water (USP apparatus II technique). During the experiment, the temperature was maintained at 37 ± 0.5oC and the paddles rotated at 50 rpm [19]. Five milliliter samples were collected at 10, 20, 30, and 45 minutes. To maintain the volume uniform throughout the experiment, an equal volume of dissolving liquid was used. After the samples were removed and diluted using the same medium, the amount of medication dissolved was measured using a UV spectrophotometer with a 278 nm wavelength. Properties of solid dissolution [20–22].

RESULT AND DISCUSSION

Construction of Standard Calibration Curve for Verapamil HCl in 0.1N HCl

The calibration curve for verapamil HCl using 0.1 N HCl and 6.8 phosphate buffer is shown in the picture below. The curve was linear across concentrations of 1-5 µg/ml, with a regression coefficient of 0.987. The calibration curve follows Beer's law when the regression value is high (Table 3, 4) (Figure 1, 2).

Table 3. Standard calibration curve for verapamil HCl in 0.1NHCl.

S.N.	Conc (µg/ml)	Absorbance at278 (nm)
1	0	0
2	1	0.012
3	2	0.020
4	3	0.032
5	4	0.043
6	5	0.051

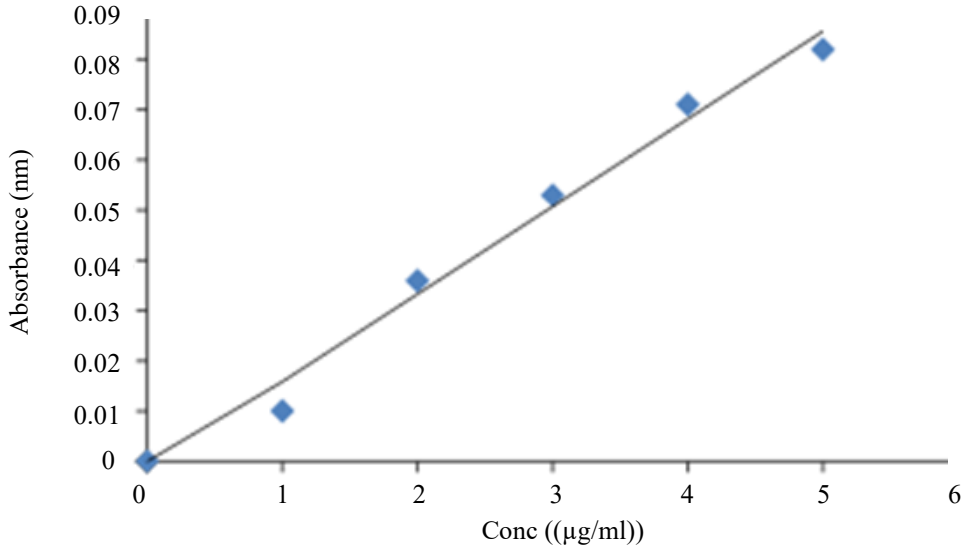

Figure 1. Calibration curve of verapamil HCL in 0.1N HCL.

Table 4. Calibration curve for verapamil HCl in 6.8 phosphate buffer.

S.N.	Conc (µg/ml)	Absorbance at 278nm
1	0	0
2	1	0.010
3	2	0.036
4	3	0.053
5	4	0.071
6	5	0.082

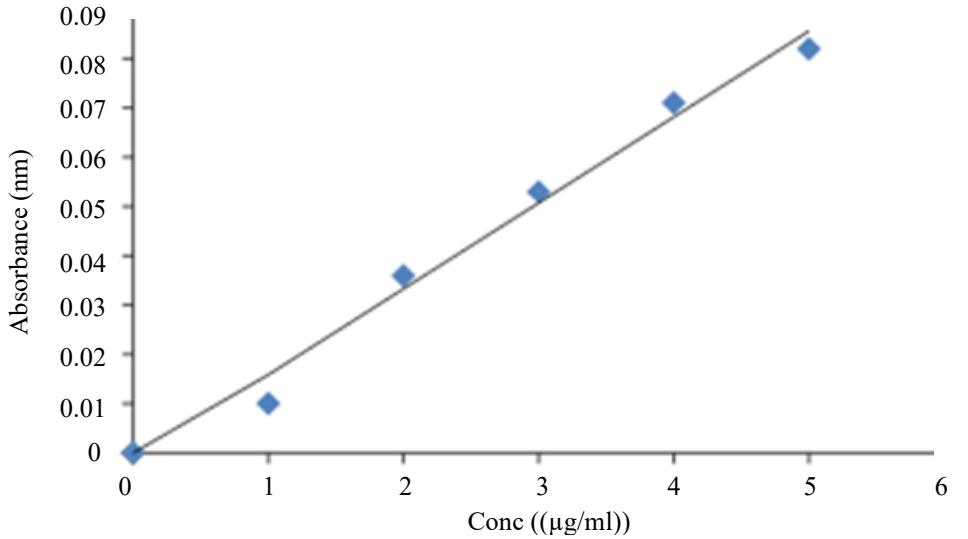

Figure 2. Calibration curve of verapamil HCL in 6.8 phosphate buffer.

Solubility Studies

Solubility of Verapamil HCl

Verapamil's saturation solubility in water was determined to be 0.008 mg/ml, indicating that the drug is only very weakly soluble in water. It also exhibits good solubility in methanol and chloroform, with corresponding solubility values of 0.25 mg/ml and 1.6 mg/ml. It suggests that for preparing a solid dispersion for the solvent evaporation process, methanol and chloroform are suitable solvent choices. Solubility data of drug Verapamil in various liquid vehicles is shown in Table 5.

Table 5. Solubility of drug in different solvents.

Solvent	Solubility (mg/ml)
Methanol	0.25
Chloroform	1.6
Ethanol	0.18
Water	0.003
Tween 80	0.21

Solubility of Solid Dispersion of Verapamil by Solvent Evaporation Method and Fusion Method

Solid Dispersion of Verapamil in water was shown to have a saturated solubility of 0.12 and 0.20 mg/ml, indicating that the drug is more soluble in water. It also exhibits good solubility in methanol and chloroform, with solubility levels of 0.51 and 0.55 mg/ml and 2.6 and 2.9 mg/ml, respectively. It suggests that for preparing a solid dispersion for the solvent evaporation process, methanol and chloroform are suitable solvent choices (Table 6–8). Verapamil in's solid dispersion solubility data in several liquid vehicles is shown in Table 6.

Table 6. Solubility of drug in different solvents.

Solvent	Solubility (mg/ml) By Solvent Evaporation	Solubility(mg/ml) By Fusion Method
Methanol	0.51	0.55
Chloroform	2.6	2.9
Ethanol	0.28	0.36
Water	0.12	0.20
Tween 80	0.51	0.59

Table 7. Drug release profile of verapamil solid dispersions by solvent evaporation method.

Time (min)	Cumulative % Drug Release				
	VE	*VE1*	*VE2*	*VE3*	*VE4*
0	0	0	0	**0**	0
10	2	8	11	14	9
20	7	20	23	56	45
30	12	56	61	77	73
45	19	63	72	93	82

Table 8. Drug release profile of verapamil solid dispersions by fusion method.

Time (min)	Cumulative % Drug Release				
	VF	*VF1*	*VF2*	*VF3*	*VF4*
0	0	0	0	0	0
10	2	16	18	11	13
20	7	52	76	67	63
30	12	71	87	72	71
45	19	85	95	81	83

CONCLUSION

Verapamil is a member of the calcium-channel blocker drug class. It works well to suppress arrhythmias as an antiarrhythmic medication. Myocardial infarction and cardiomyopathy are supported by its potent vasodilation and adverse inotropic effects. Because of its low water solubility and oral bioavailability, methods like solid dispersion have been developed to increase its solubility. Solvent evaporation Methos used PEG 6000 and Cyclodextrin to create the solid dispersion formulations, while the Fusion Method used PEG 4000 and HPMC.A variety of characteristics, including solubility and in vitro drug release behavior, were assessed for the produced formulations. It was concluded from the results that, in comparison to other formulations made using solvent evaporation techniques, formulation VF2, which was made by solid dispersion, demonstrated a greater extent of drug release. Based on this work, it is

feasible to increase Verapamil's solubility through solid dispersion. In the future, the generated solid dispersion of verapamil can be used to formulate solid oral dosage forms (tablets, capsules) of the medication, increasing both its oral bioavailability and solubility. Verapamil solid dispersions' increased rates of dissolution are evident from this investigation. The statistics clearly show that a larger concentration of polymers results in a faster release of the medication. Therefore, one of the most promising methods for increasing the solubility of drugs that are poorly soluble in water is solid dispersion.

REFERENCES

1. Panchal DM, Tiwari AK. Research on improvisation in dissolution of Olmesartan medoxomil by enhancing its solubility using solid dispersion techniques. World J Pharm Res. 2013;2(5):1793–816.
2. Chaudhary A, Nagaich U, Gulati N, Sharma VK, Khosa RL. Enhancement of solubilization and bioavailability of poorly soluble drugs by physical and chemical modifications: A recent review. J Adv Pharm Educ Res. 2012;2(1):32–67.
3. Ali Sajid M, Choudhary V. Solubility enhancement methods with importance of hydrotropy. J Drug Deliv Ther. 2012;2(6):96–101.
4. Kadam SV, Shinkar DM, Saudagar RB. Review on solubility enhancement techniques. Int J Pharm Bio Sci. 2013;3(3):462–75.
5. Behera AL, Sahoo SK, Patil SV. Enhancement of solubility: A pharmaceutical overview. Sch Res Libr. 2010;2(2):310–18.
6. Patel JN, Rathod DM, Patel NA, Moin KM. Techniques to improve the solubility of poorly soluble drugs. Int J Pharm Life Sci. 2012;3(2):1459–69.
7. Nikghalb LA, Singh G, Kahkeshan KF. Solid dispersion: Methods and polymers to increase the solubility of poorly soluble drugs. J Appl Pharm Sci. 2012;2(10):170–75.
8. Kommu A, Chebrolu JB, Laksmaiah P, Rao CB, Buchiraju R, Pathapati H. Techniques to improve the absorption of poorly soluble drugs. Int J Res Pharm Chem. 2012;2(2):533–40.
9. Kataria MK, Bhandari A. Solubility and dissolution enhancement: Technologies and research emerged. J Biol Sci Opin. 2013;1(2):105–16.
10. Thakur AK, Nirmala, Harikumar SL. Various techniques enhancing bioavailability of poorly water-soluble drugs. J Drug Deliv Ther. 2013;3(2):215–21.
11. Choudhary NR, Reddy AT, Srinivasan S, Kavitha K, Kumar R, Singh J. Review on: Better solubility enhancement of poorly water-soluble drugs. Int J Inv Pharm Sci. 2013;1(4):267–73.
12. Kaur J, Aggarwal G, Singh G, Rana AC. Improvement of drug solubility using solid dispersion. Int J Pharm Pharm Sci. 2012;4(2):47–53.
13. Patil SK, Kalpesh SW, Venkatesh BP, Anup MA, Dheeraj TB. Strategies for solubility enhancement of poorly soluble drugs. Int J Pharm Sci Rev Res. 2011;8(2):74–80.
14. Sareen S, Mathew G, Joshep L. Improvement in solubility of poorly water-soluble drugs by solid dispersion. Int J Pharm Investig. 2012;2(1):12–7.
15. Chowdary KPR, Kumar AP. Recent research on formulation development of BCS class II drugs – A review. Int Res J Pharm App Sci. 2013;3(1):173–81.
16. Ghosh I, Bose S, Vippagunta R, Ferris H. Nanosuspension for improving the bioavailability of a poorly soluble drug and screening of stabilizing agents to inhibit crystal growth. Int J Pharm. 2011;409:260–68.
17. Vikas AS, Kukkar V, Kataria M, Gera M, Choudhury PK. Dissolution enhancement of drugs. Part I: Technologies and effect of carriers. Int J Health Res. 2009;2(2):107–24.
18. Serajuddin ATM. Salt formation to improve drug solubility. Adv Drug Deliv Rev. 2007;59:603–16.
19. Vemula VR, Lagishetty V, Lingala S. Solubility enhancement techniques. Int J Pharm Sci Rev Res. 2010;5(1):41–51.
20. Dhillon B, Goyal NK, Malviya R, Sharma PK. Poorly water-soluble drugs: Change in solubility for improved dissolution characteristics – a review. Glob J Pharmacol. 2014;8(1):26–35.
21. Mogal SA, Gurjar PN, Yamgar DS, Kamod AC. Solid dispersion technique for improving solubility of some poorly soluble drugs. Der Pharm Lett. 2012;4(5):1574–86.
22. Sinha S, Ali M, Sanjula B, Ahuja A, Kumar A, Ali J. Solid dispersion as an approach for bioavailability enhancement of poorly water-soluble drug Ritonavir. AAPS PharmSciTech. 2010;11(2):518–27.

