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Enhancement of Glipizide Dissolution by Poloxamer 188-Based Amorphous Solid Dispersion and Development of Immediate-Release Tablets

Jaimin B Patel*[1], Upendra patel[2]
[1]Research Scholar (Associate professor), Swarrnim Startup and Innovation University, Gandhinagar, Gujarat, India.
[2]Principal, Aarihant School of Pharmacy Swarrnim Startup and Innovation University. Gandhinagar, Gujarat, India.
*Corresponding Author E-mail: **jaiminpatel0522@gmail.com**

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ABSTRACT:
Glipizide, a second-generation sulfonylurea used in the management of type II diabetes mellitus, exhibits poor aqueous solubility, resulting in a slow dissolution rate and limited oral bioavailability. The present study aimed to improve the dissolution characteristics of glipizide by developing amorphous solid dispersions using hydrophilic carriers and formulating the optimized dispersion into immediate-release tablets. Amorphous solid dispersions were prepared by the melting method using polyethylene glycol (PEG) 6000, PEG 8000, and Poloxamer 188 at different drug-to-carriers ratios. Phase solubility studies demonstrated that Poloxamer 188 exhibited the highest solubilization capacity, increasing the aqueous solubility of glipizide from 0.0345 mg/mL to 0.2562 mg/mL, compared with 0.1945 mg/mL for PEG 8000 and 0.1404 mg/mL for PEG 6000. Drug content of the prepared solid dispersions ranged from 95.31% to 99.02%, indicating satisfactory drug incorporation. Among all formulations, the glipizide–Poloxamer 188 (1:2) solid dispersion exhibited superior dissolution performance, achieving 82.70 ± 3.00% drug release within 5 min, 86.33 ± 4.39% at 15 min, and approximately 100% drug release within 90 min. FTIR analysis confirmed the absence of significant drug–carrier interactions, while PXRD analysis demonstrated a marked reduction in drug crystallinity following solid dispersion formation. The optimized solid dispersion was successfully formulated into immediate-release tablets that exhibited acceptable physicochemical properties, including hardness of 6.22–6.55 kg/cm², friability of 0.523–1.011%, assay of 100.26–104.78%, and disintegration time of 5.23–6.87 min. The optimized tablet formulation achieved 99.76 ± 1.67% drug release within 60 min, demonstrating superior dissolution compared with the marketed formulation. These findings indicate that Poloxamer 188-based amorphous solid dispersion prepared by the melting method is an effective approach for enhancing the solubility, dissolution rate, and immediate-release performance of glipizide, thereby offering a promising strategy for improving the oral delivery of poorly water-soluble drugs.

1. INTRODUCTION:

Poor aqueous solubility is a major challenge in oral drug delivery, as it limits the dissolution rate and consequently reduces the bioavailability of many therapeutic agents. Drugs belonging to the Biopharmaceutics Classification System (BCS) Class II exhibit high permeability but low solubility, making dissolution the rate-limiting step for absorption [1]. Among the various formulation strategies developed to overcome this limitation, amorphous solid dispersion (ASD) has emerged as an effective approach because it improves drug wettability, reduces crystallinity, and enhances dissolution. Glipizide is a second-generation sulfonylurea widely used for the treatment of type 2 diabetes mellitus. Despite its high permeability, its poor aqueous solubility results in slow dissolution and variable oral bioavailability [2]. Therefore, improving its dissolution behavior is essential to achieve rapid and consistent

therapeutic performance. Hydrophilic carriers such as PEG 6000, PEG 8000, and Poloxamer 188 have been extensively investigated for the preparation of amorphous solid dispersions. PEGs enhance drug wettability and dispersion within the carrier matrix, whereas Poloxamer 188, owing to its amphiphilic nature, further improves drug solubilization through micellar formation and inhibition of drug recrystallization. The melting (fusion) method offers a simple, solvent-free, and scalable technique for preparing amorphous solid dispersions with improved dissolution characteristics [3]. Therefore, the present study aimed to develop glipizide amorphous solid dispersions using PEG 6000, PEG 8000, and Poloxamer 188 by the melting method and to compare their effects on drug dissolution. The optimized formulation was further characterized by FTIR and PXRD, formulated into immediate-release tablets, and evaluated for its physicochemical properties and comparative in vitro dissolution performance against a marketed formulation.

2. MATERIALS AND METHODS:

2.1 Materials:

Glipizide was selected as the model drug for the preparation of amorphous solid dispersions due to its poor aqueous solubility. Polyethylene glycol 6000 (PEG 6000), polyethylene glycol 8000 (PEG 8000), and Poloxamer 188 were employed as hydrophilic carriers for solubility enhancement. Sodium starch glycolate (SSG) was used as the superdisintegrant, microcrystalline cellulose (MCC) as the diluent, lactose as the filler, talc as the glidant, and magnesium stearate as the lubricant during tablet formulation. All chemicals and reagents used in the study were of analytical grade and were used without further purification.

2.2 Instruments:

The experimental work was carried out using a UV–Visible spectrophotometer for quantitative drug estimation, Fourier-transform infrared (FTIR) spectrophotometer for compatibility studies, powder X-ray diffractometer (PXRD) for crystallinity analysis, differential scanning calorimeter (DSC) for thermal characterization, scanning electron microscope (SEM) for surface morphology evaluation, USP Type II dissolution apparatus (paddle type) for dissolution studies, disintegration test apparatus, sonicator, electronic analytical balance, digital pH meter, and hot plate.

2.3 Preparation of Standard Calibration Curve of Glipizide:

A standard stock solution of glipizide was prepared in phosphate buffer (pH 6.8). Appropriate aliquots of the stock solution were diluted with the same dissolution medium to obtain concentrations of 5, 10, 15, 20, 25, 30, and 35 µg/mL. The absorbance of each solution was measured at 276 nm using a UV–Visible spectrophotometer with phosphate buffer (pH 6.8) as the blank. The calibration curve was constructed by plotting absorbance against concentration, and the calibration data used for quantitative estimation of glipizide [4].

2.4 Phase Solubility Study:

The phase solubility study was carried out according to the method described by Higuchi and Connors to evaluate the influence of hydrophilic carriers on the aqueous solubility of glipizide. Excess glipizide was added separately to aqueous solutions containing different concentrations (0–12% w/v) of PEG 6000, PEG 8000, and Poloxamer 188. The resulting suspensions were continuously agitated at 37 ± 2°C until equilibrium was achieved. Following equilibration, the samples were filtered through Whatman filter paper to remove undissolved drug. The filtrates were suitably diluted with phosphate buffer (pH 6.8), and the concentration of dissolved glipizide was determined spectrophotometrically at 276 nm. The solubility of glipizide in the presence of different carrier concentrations was subsequently calculated and used to evaluate the solubilization efficiency of each carrier [5].

2.5 Preparation of Amorphous Solid Dispersions:

Amorphous solid dispersions of glipizide were prepared using the melting (fusion) method. Accurately weighed quantities of PEG 6000, PEG 8000, and Poloxamer 188 were separately placed in porcelain dishes and melted on a thermostatically controlled water bath maintained at approximately 60°C. An accurately weighed quantity of glipizide was gradually incorporated into the molten carrier under continuous stirring using a glass rod until a homogeneous molten mixture was obtained. The mixture was maintained at approximately 10°C above the melting temperature of the respective carrier for about 5 min to ensure complete dispersion of the drug within the polymeric matrix. The molten mass was then allowed to cool at room temperature until complete solidification [6]. The

solidified mass was pulverized using a mortar and pestle, passed through a suitable sieve to obtain a uniform particle size, and stored in a desiccator until further characterization. The formulations prepared using different drug-to-carriers ratios are listed in Table 1.

Table 1. Drug-to-carriers ratio of glipizide amorphous solid dispersions prepared by the melting method.

Carrier	Drug: carriers' ratio
PEG 6000	1:1, 1:3, 1:5, 1:7, 1:9
PEG 8000	1:1, 1:3, 1:5, 1:7, 1:9
Poloxamer 188	1:1, 1:2, 1:3, 1:7, 1:9

2.6 Evaluation of Amorphous Solid Dispersions

2.6.1 Drug Content Determination

The drug content of each solid dispersion formulation was determined by accurately weighing a quantity of solid dispersion equivalent to 10 mg of glipizide. The sample was transferred into a volumetric flask containing phosphate buffer (pH 6.8) and sonicated until complete dissolution. The resulting solution was filtered through Whatman filter paper, appropriately diluted with phosphate buffer (pH 6.8), and analyzed spectrophotometrically at 276 nm. The drug content was calculated using the calibration equation obtained from the standard calibration curve [7].

2.6.2 In Vitro Dissolution Study of Solid Dispersions

The in vitro dissolution study of pure glipizide and all prepared solid dispersion formulations was carried out using a USP Type II (paddle) dissolution apparatus. Dissolution was performed in 900 mL of phosphate buffer (pH 6.8) maintained at 37 ± 0.5°C with a paddle rotation speed of 50 rpm. Samples were withdrawn at predetermined time intervals of 5, 15, 30, 45, 60, 75, and 90 min, filtered through Whatman filter paper, and analyzed spectrophotometrically at 276 nm. After each sampling, an equal volume of fresh dissolution medium maintained at the same temperature was added to maintain a constant dissolution volume and sink conditions throughout the study. The dissolution efficiency (DE), percentage drug dissolved at 5 min (Q_5), percentage drug dissolved at 15 min (Q_{15}), and other dissolution parameters were calculated according to standard procedures for comparative evaluation of the formulations [8].

2.7 Characterization of Optimized Amorphous Solid Dispersion

2.7.1 Fourier Transform Infrared (FTIR) Spectroscopy

Fourier-transform infrared (FTIR) spectroscopy was performed to investigate the compatibility between glipizide and the selected carrier and to identify any possible physicochemical interactions following solid dispersion preparation. FTIR spectra of pure glipizide, the selected carrier, and the optimized solid dispersion were recorded using the potassium bromide (KBr) pellet technique over the spectral range of 4000–400 cm^{-1}**.** The characteristic absorption bands of the pure drug and formulation were compared to evaluate possible changes in functional groups [9].

2.7.2 Powder X-ray Diffraction (PXRD)

Powder X-ray diffraction analysis was performed to evaluate the crystalline characteristics of pure glipizide, the selected carrier, and the optimized amorphous solid dispersion. The samples were scanned using an X-ray diffractometer over an appropriate 2θ range under standard operating conditions. The obtained diffraction patterns were used to assess changes in the crystalline nature of the drug following incorporation into the carrier matrix [10].

2.8 Preparation of Immediate-Release Tablets

The optimized glipizide amorphous solid dispersion was formulated into immediate-release tablets by the direct compression method. The required quantity of solid dispersion equivalent to 10 mg of glipizide was accurately weighed and blended with sodium starch glycolate (SSG), microcrystalline cellulose (MCC), lactose, talc, and magnesium stearate according to the formulation composition. All ingredients were passed through sieve No. 60 before blending. The powder blend was mixed uniformly, followed by the addition of talc and magnesium stearate as lubricants [11]. The final blend was compressed using a rotary tablet compression machine equipped with appropriate punches to obtain tablets of uniform weight. The composition of the tablet formulations is presented in Table 2.

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Table 2. Composition of immediate-release tablets

Ingredients (mg/tablet)	F1	F2	F3	F4	F5	F6
Glipizide solid dispersion (Equivalent to 10 mg Glipizide)	30	30	30	30	30	30
Sodium starch glycolate	2	2	2	2	2	2
Microcrystalline cellulose	15	20	25	30	35	40
Talc	1	1	1	1	1	1
Magnesium stearate	2	2	2	2	2	2
Lactose	100	95	90	85	80	75
Total weight (mg)	150	150	150	150	150	150

2.9 Pre-compression Evaluation of Powder Blend

2.9.1 Bulk Density

Bulk density was determined by gently transferring a known quantity of powder into a graduated measuring cylinder without compacting the powder [12]. The bulk volume was recorded, and bulk density was calculated using the following equation:

$$\text{Bulk Density} = \frac{\text{Weight of Powder}}{\text{Bulk Volume}}$$

2.9.2 Tapped Density

The graduated cylinder containing the powder was tapped mechanically until a constant volume was obtained. The tapped density was calculated using the following equation:

$$\text{Tapped Density} = \frac{\text{Weight of Powder}}{\text{Tapped Volume}}$$

2.9.3 Carr's Compressibility Index

Carr's Compressibility Index was calculated from the bulk density and tapped density values using the following equation:

$$\text{Carr's Index (\%)} = \frac{\text{Tapped Density} - \text{Bulk Density}}{\text{Tapped Density}} \times 100$$

2.9.4 Hausner's Ratio

Hausner's ratio was calculated using the equation:

$$\text{Hausner's Ratio} = \frac{\text{Tapped Density}}{\text{Bulk Density}}$$

2.9.5 Angle of Repose

The angle of repose was determined using the fixed funnel method. The powder blend was allowed to flow freely through a funnel onto a flat surface to form a conical heap. The angle of repose (θ) was calculated using the following equation:

$$\theta = \tan^{-1} \text{ (h/r)}$$

Where, **h** is the height of the powder cone and **r** is the radius of the cone.

2.9.6 Particle Size Distribution

Particle size distribution of the optimized solid dispersion was determined by standard sieve analysis using a set of standard sieves arranged in descending order of aperture size. The percentage of material retained on each sieve was recorded to determine the particle size range [13].

2.9.7 Porosity

The porosity of the powder blend was determined using the relationship between bulk density and true density and expressed as the percentage void volume present within the powder bed.

2.10 Evaluation of Immediate-Release Tablets

The compressed tablets were evaluated according to the procedures described in the Indian Pharmacopoeia (IP) and the United States Pharmacopeia (USP).

2.10.1 Physical Appearance
The tablets were visually inspected for colour, surface texture, shape, uniformity, and the presence of any visible defects such as chipping or capping.

2.10.2 Thickness
Tablet thickness was measured using a digital Vernier caliper, and the average value was calculated from six tablets.

2.10.3 Weight Variation
Twenty tablets were individually weighed using an analytical balance. The average tablet weight and percentage deviation from the average weight were calculated according to Pharmacopeial specifications.

2.10.4 Hardness
Tablet hardness was determined using a Monsanto hardness tester, and the crushing strength was expressed in kg/cm^2.

2.10.5 Friability
Friability was determined using a Roche friabilator operated at 25 rpm for 4 min (100 revolutions). Tablets were weighed before and after the test, and the percentage friability was calculated.

2.10.6 Drug Content (Assay)
Ten tablets were powdered, and a quantity of powder equivalent to 10 mg of glipizide was dissolved in phosphate buffer (pH 6.8), filtered, suitably diluted, and analyzed using a UV-Visible spectrophotometer at 276 nm [14].

2.10.7 In Vitro Disintegration Time
The disintegration time was determined using a USP disintegration test apparatus containing distilled water maintained at 37 ± 0.5°C. The time required for complete disintegration of each tablet was recorded [15].

2.11 In Vitro Dissolution Study of Immediate-Release Tablets
The in vitro dissolution study of the prepared immediate-release tablets and the marketed reference formulation was performed using a USP Type II (paddle) dissolution apparatus. Dissolution was carried out in 900 mL of phosphate buffer (pH 6.8) maintained at 37 ± 0.5°C with a paddle speed of 50 rpm. Samples were withdrawn at predetermined time intervals of 5, 15, 30, 45, 60, 75, and 90 min, filtered, and analyzed spectrophotometrically at 276 nm. After each sampling, an equal volume of fresh dissolution medium maintained at the same temperature was added to maintain a constant volume throughout the study. The dissolution profile of each formulation was compared with that of the marketed product using standard model-independent parameters, including the similarity factor (f_2), difference factor (f_1), dissolution efficiency (DE), and mean dissolution time (MDT) [16].

3. RESULTS AND DISCUSSION:
3.1 Preparation of Standard Calibration Curve of Glipizide
The calibration data and corresponding calibration curve of glipizide are presented in Figure 1, respectively. A linear increase in absorbance was observed with increasing glipizide concentration over the range of 5–35 μg/mL, with absorbance values increasing from 0.118 to 0.819. The excellent linear relationship between concentration and absorbance confirmed compliance with Beer–Lambert's law, indicating that the developed UV spectrophotometric method was suitable for the quantitative estimation of glipizide throughout the study.

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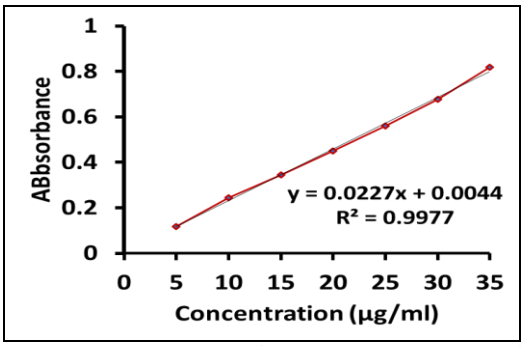

Figure 1. Standard calibration curve of glipizide in phosphate buffer (pH 6.8).

3.2 Phase Solubility Study

The phase solubility profile of glipizide in the presence of PEG 6000, PEG 8000, and Poloxamer 188 is shown in Figure 2. The aqueous solubility of glipizide increased progressively with increasing carrier concentration (0–12% w/v) for all investigated carriers. Among them, Poloxamer 188 exhibited the highest solubilization effect, increasing the solubility from 0.0345 mg/mL to 0.2562 mg/mL at 12% (w/v), followed by PEG 8000 (0.1945 mg/mL) and PEG 6000 (0.1404 mg/mL). The superior solubilization performance of Poloxamer 188 can be attributed to its amphiphilic nature, which enhances drug wettability and micellar solubilization, whereas PEG 6000 and PEG 8000 primarily improve solubility through enhanced wettability and hydrogen-bond interactions. These findings indicate that Poloxamer 188 is the most effective carrier for improving the aqueous solubility of glipizide and was therefore selected for the preparation of optimized amorphous solid dispersions (Figure 2).

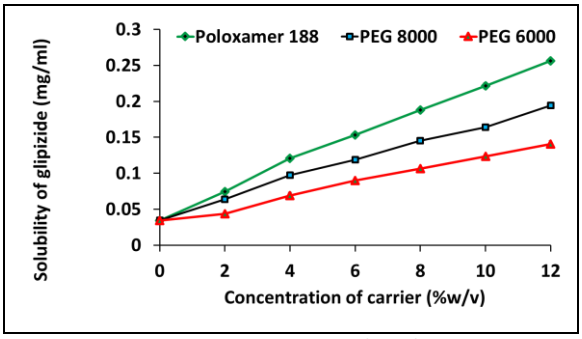

Figure 2. Phase solubility profile of glipizide

3.3 Evaluation of Drug Content of Amorphous Solid Dispersions

The drug content of the prepared amorphous solid dispersions ranged from 95.31% to 99.02%, indicating satisfactory incorporation of glipizide into the carrier matrix with minimal drug loss during formulation. The narrow variation in drug content demonstrated excellent content uniformity and confirmed the reproducibility of the melting method. These findings indicate that the prepared solid dispersions were chemically stable and suitable for subsequent dissolution and physicochemical characterization studies.

3.4 In Vitro Dissolution Study of Amorphous Solid Dispersions

3.4.1 Glipizide Solid Dispersions Prepared with PEG 6000

The dissolution profiles of glipizide solid dispersions prepared using PEG 6000 are presented in Figure 3. All PEG 6000 formulations showed improved dissolution compared with pure glipizide, with drug release increasing progressively as the polymer concentration increased. The PEG 6000 (1:9) formulation exhibited the highest dissolution, achieving 53.36 ± 1.26% drug release at 5 min, 56.83 ± 1.78% at 15 min, and 100.11 ± 3.66% at 90 min, whereas pure glipizide released only 6.17 ± 3.16%, 16.52 ± 2.20%, and 47.90 ± 2.90%, respectively. The enhanced dissolution can be attributed to the hydrophilic nature of PEG 6000, which improves drug wettability and dispersion within the carrier matrix, thereby facilitating faster dissolution of glipizide. However, the dissolution enhancement obtained with PEG 6000 was lower than that observed with PEG 8000 and Poloxamer 188 (Figure 3).

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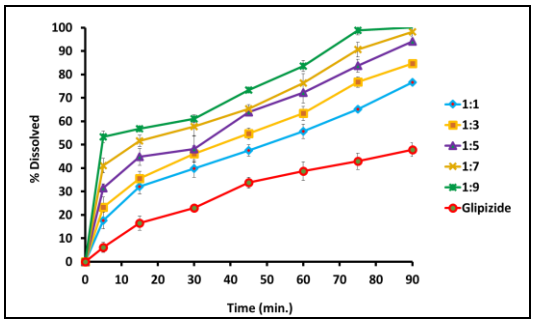

Figure 3. In Vitro Dissolution Profiles Of Glipizide Solid Dispersions Prepared Using Peg 6000.

3.4.2 Glipizide Solid Dispersions Prepared with PEG 8000

The dissolution profiles of glipizide solid dispersions prepared using PEG 8000 are presented in Figure 4. All PEG 8000 formulations exhibited significantly improved dissolution compared with pure glipizide, with drug release increasing as the polymer concentration increased. The PEG 8000 (1:9) formulation showed the highest dissolution, achieving 60.49 ± 2.45% drug release at 5 min, 65.98 ± 0.75% at 15 min, and 100.74 ± 3.66% at 90 min, whereas pure glipizide released only 6.17 ± 3.16%, 16.52 ± 2.20%, and 47.90 ± 2.90%, respectively. The enhanced dissolution may be attributed to the hydrophilic nature of PEG 8000, which improves drug wettability and dispersion within the carrier matrix, thereby facilitating faster drug dissolution. Nevertheless, the dissolution performance of PEG 8000 remained lower than that achieved with Poloxamer 188, indicating that the latter was a more effective carrier for enhancing glipizide dissolution (Figure 4).

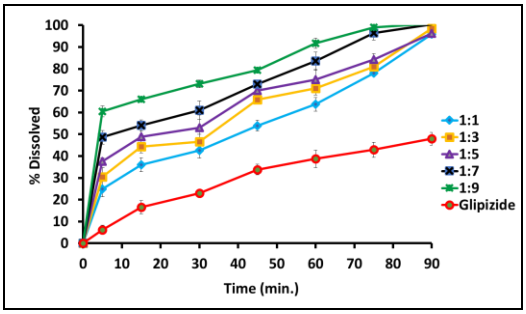

Figure 4. IN VITRO DISSOLUTION PROFILES OF GLIPIZIDE SOLID DISPERSIONS PREPARED USING PEG 8000.

3.4.3 Glipizide Solid Dispersions Prepared with Poloxamer 188

The dissolution profiles of glipizide solid dispersions prepared using Poloxamer 188 are presented in Figure 5. All Poloxamer 188 formulations exhibited significantly higher drug release than pure glipizide and the PEG-based solid dispersions. The 1:2 drug-to-carriers ratio demonstrated the highest dissolution performance, achieving 82.70 ± 3.00% drug release within 5 min, 86.33 ± 4.39% at 15 min, and 100.42 ± 0.54% at 90 min. In comparison, pure glipizide released only 6.17 ± 3.16%, 16.52 ± 2.20%, and 47.90 ± 2.90% at the corresponding time points. The marked improvement in dissolution can be attributed to the amphiphilic nature of Poloxamer 188, which enhances drug wettability, promotes micellar solubilization, and reduces drug crystallinity, resulting in rapid and extensive dissolution. Based on the dissolution profile, the glipizide–Poloxamer 188 (1:2) formulation was selected as the optimized formulation for subsequent characterization and tablet development (Figure 5).

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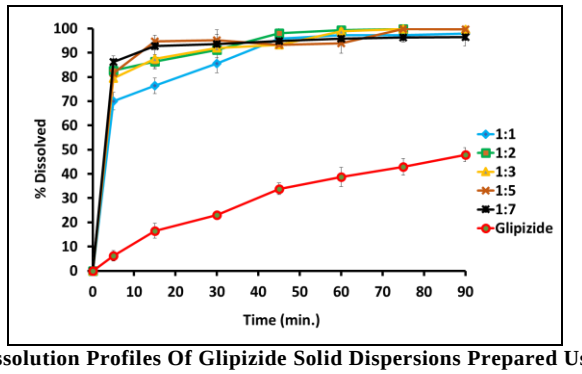

Figure 5. In Vitro Dissolution Profiles Of Glipizide Solid Dispersions Prepared Using Poloxamer 188.

3.5 Dissolution Parameters of Amorphous Solid Dispersions

The dissolution parameters of pure glipizide and the prepared amorphous solid dispersions are in Table 3. Pure glipizide exhibited the lowest dissolution performance, with Q_5 = 6.17 ± 3.16%, Q_{15} = 16.51 ± 2.20%, DE_5 = 3.08, and DE_{15} = 8.59, reflecting its poor aqueous solubility. A progressive increase in dissolution parameters was observed with increasing carrier concentration for both PEG 6000 and PEG 8000 formulations. Among these, the PEG 8000 (1:9) formulation showed higher dissolution values (Q_5 = 60.49 ± 2.45%, Q_{15} = 65.98 ± 0.75%, DE_5 = 30.24, and DE_{15} = 52.24) than the corresponding PEG 6000 formulation (Q_5 = 53.36 ± 1.26%, Q_{15} = 56.83 ± 1.78%, DE_5 = 26.67, and DE_{15} = 45.62). The Poloxamer 188 formulations exhibited the greatest enhancement in dissolution, with the 1:2 drug-to-carriers ratio providing the highest dissolution efficiency (Q_5 = 82.70 ± 3.00%, Q_{15} = 86.33 ± 4.39%, DE_5 = 41.34, and DE_{15} = 70.12). These findings demonstrate the superior ability of Poloxamer 188 to enhance the dissolution of glipizide through improved wettability and reduced drug crystallinity. Accordingly, the glipizide–Poloxamer 188 (1:2) formulation was selected as the optimized formulation for further physicochemical characterization and immediate-release tablet development.

Table 3. Dissolution parameters of glipizide alone and its Amorphous Solid Dispersions

Formulation	Ratio	Q_5 min	Q_{15} min	%DE_5 min	%DE_{15} min
Glipizide	–	6.17 ± 3.16	16.51 ± 2.20	3.08	8.59
Solid dispersion with PEG 6000	1:1	17.67 ± 0.67	32.05 ± 1.58	8.83	19.51
	1:3	23.23 ± 1.55	35.65 ± 3.67	11.61	23.49
	1:5	31.55 ± 2.55	44.81 ± 0.64	15.77	30.71
	1:7	41.07 ± 3.34	51.60 ± 2.15	20.53	37.73
	1:9	53.36 ± 1.26	56.83 ± 1.78	26.67	45.62
Solid dispersion with PEG 8000	1:1	24.81 ± 2.35	36.05 ± 1.79	12.40	24.42
	1:3	30.36 ± 2.35	44.41 ± 1.79	15.18	29.98
	1:5	37.50 ± 0.52	48.81 ± 2.98	18.74	35.01
	1:7	48.60 ± 1.55	54.02 ± 2.68	24.30	42.30
	1:9	60.49 ± 2.45	65.98 ± 0.75	30.24	52.24
Solid dispersion with Poloxamer 188	1:1	70.01 ± 2.91	76.35 ± 3.56	35.00	60.45
	1:2	82.70 ± 3.00	86.33 ± 4.39	41.34	70.12
	1:3	79.53 ± 3.81	87.50 ± 1.79	39.76	68.92
	1:7	81.51 ± 1.94	94.65 ± 3.08	40.75	72.30
	1:9	86.27 ± 3.35	92.69 ± 5.71	43.13	74.02

3.6 Fourier Transform Infrared (FTIR) Spectroscopy

The FTIR spectra of pure glipizide, Poloxamer 188, and the optimized glipizide–Poloxamer 188 solid dispersion are presented in Figures 6–8, respectively. The optimized solid dispersion retained the characteristic absorption peaks of glipizide with only minor variations in peak intensity and broadening. No additional peaks or disappearance of the characteristic peaks were observed, indicating the absence of significant chemical interaction between glipizide and Poloxamer 188. These findings confirm the compatibility of the drug with the selected carrier and demonstrate that the formulation process did not alter the chemical structure of glipizide.

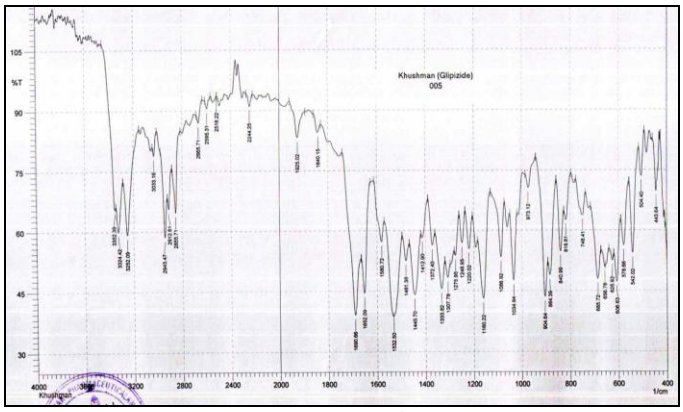

Figure 6. FTIR Spectrum Of Pure Glipizide.

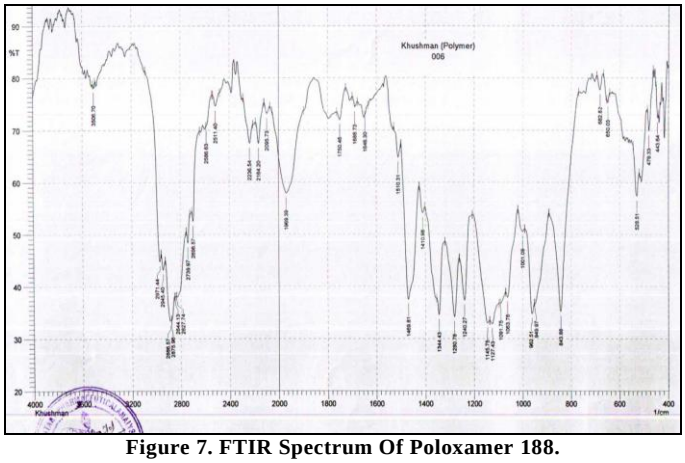

Figure 7. FTIR Spectrum Of Poloxamer 188.

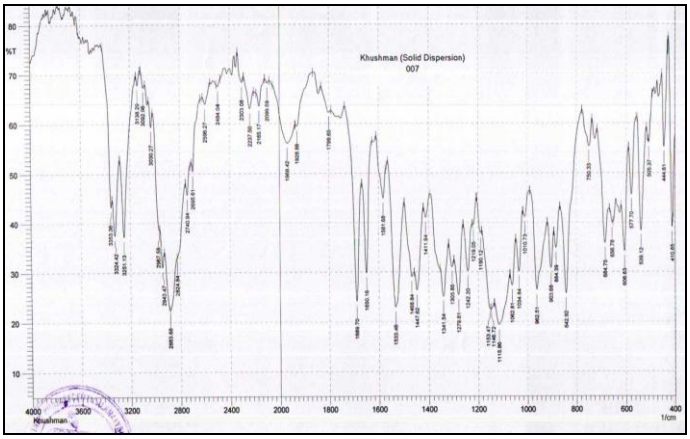

Figure 8. FTIR Spectrum Of Optimized Glipizide–Poloxamer 188 Amorphous Solid Dispersion.

3.7 Powder X-ray Diffraction (PXRD) Analysis

The PXRD patterns of pure glipizide, Poloxamer 188, and the optimized glipizide-Poloxamer 188 solid dispersion are presented in Figures 9–11. Pure glipizide exhibited a sharp diffraction peak at $2\theta = 15.754°$ with 100% intensity (Figure 9), confirming its crystalline nature. In contrast, Poloxamer 188 showed a characteristic peak with 4.6% intensity (Figure 10), while the optimized solid dispersion exhibited a reduced peak intensity of 44.8% (Figure 11). The decrease in diffraction intensity indicates reduced crystallinity of glipizide after solid dispersion preparation, which contributed to the improved dissolution behavior of the optimized formulation.

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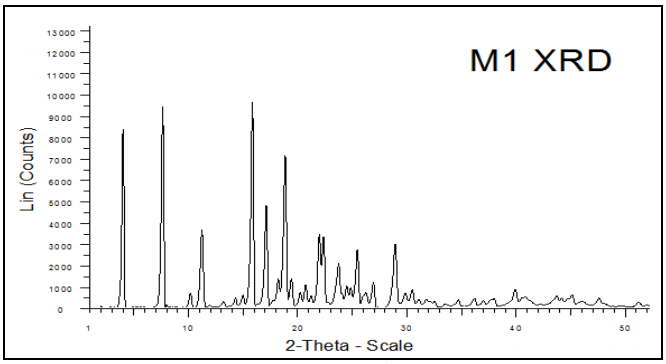

Figure 9. PXRD Pattern Of Pure Glipizide.

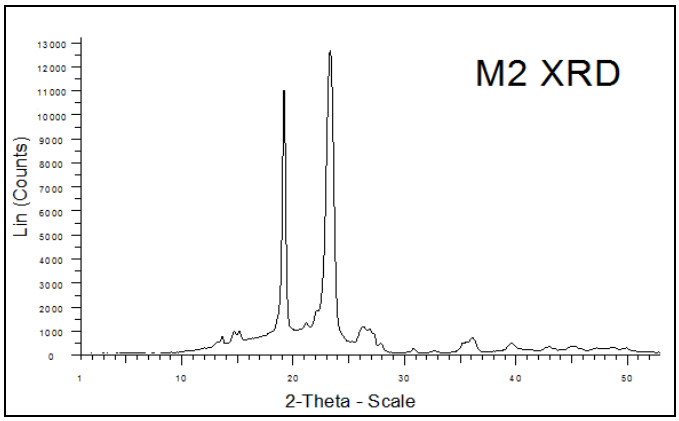

Figure 10. PXRD Pattern Of Poloxamer 188.

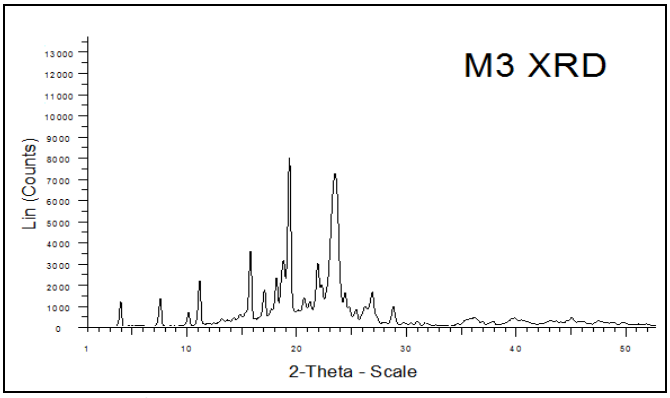

Figure 11. PXRD Pattern Of Optimized Glipizide–Poloxamer 188 Amorphous Solid Dispersion.

3.8 Evaluation of Immediate-Release Tablets

The physicochemical properties of the prepared immediate-release tablets are presented in Table 4. All formulations exhibited acceptable pharmaceutical characteristics with satisfactory thickness, weight variation, hardness, friability, assay, and disintegration time. Tablet thickness ranged from 2.93 ± 0.026 to 3.66 ± 0.030 mm, while the average tablet weight varied between 150.95 ± 3.79 and 153.84 ± 5.61 mg, indicating good uniformity of the compressed tablets. Hardness values (6.22 ± 0.19–6.55 ± 0.16 kg/cm²) demonstrated adequate mechanical strength, and friability values (0.523–1.011%) indicated acceptable resistance to abrasion. The assay values (100.26–104.78%) confirmed satisfactory drug content uniformity, whereas the disintegration time (5.23 ± 0.25–6.87 ± 0.78 min) demonstrated the rapid disintegration characteristics required for immediate-release formulations.

Table 4. Physicochemical evaluation of immediate-release tablets

Batch	Thickness (mm) (n = 6)	Weight Variation (mg) (n = 20)	Hardness (kg/cm²) (n = 20)	Friability (%)	Assay (%) (n = 10)	In vitro Disintegration Time (min) (n = 3)
F1	2.99 ± 0.010	153.84 ± 5.61	6.27 ± 0.16	0.925	100.26	5.40 ± 0.53
F2	3.08 ± 0.036	153.42 ± 5.63	6.22 ± 0.19	1.011	102.25	5.77 ± 0.15
F3	3.02 ± 0.014	150.95 ± 3.79	6.42 ± 0.12	0.624	104.78	6.80 ± 0.70
F4	2.93 ± 0.026	151.83 ± 6.11	6.23 ± 0.12	0.895	101.15	5.23 ± 0.25
F5	3.66 ± 0.030	153.22 ± 15.40	6.38 ± 0.16	0.785	103.56	6.00 ± 0.50
F6	3.01 ± 0.014	153.00 ± 4.62	6.55 ± 0.16	0.523	100.46	6.87 ± 0.78

3.9 Comparative In-Vitro Dissolution Study of Immediate-Release Tablets

The comparative dissolution profiles of the marketed glipizide tablet (Glynase) and the developed immediate-release tablet formulations are presented in Figure 12, while the corresponding dissolution data are summarized in Table 5. All formulations exhibited rapid drug release, with more than 98% of glipizide released within 60 min. Among the prepared formulations, F3 demonstrated the highest initial dissolution (22.03 ± 1.71% at 5 min) and achieved 99.76 ± 1.67% drug release at 60 min, indicating faster dissolution than the marketed product. The enhanced dissolution behavior of the developed formulations can be attributed to the incorporation of glipizide as an optimized amorphous solid dispersion with Poloxamer 188, which improved drug wettability and reduced crystallinity, together with the rapid disintegration provided by sodium starch glycolate. Overall, the developed formulations exhibited dissolution profiles comparable to or superior to the marketed formulation, confirming the effectiveness of the solid dispersion approach for improving the dissolution characteristics of glipizide.

Table 5. Comparative in vitro dissolution profile of marketed and developed immediate-release glipizide tablets.

Time (min)	Glynase	F1	F2	F3	F4	F5	F6
0	0	0	0	0	0	0	0
5	12.12 ± 3.09	18.07 ± 3.88	14.89 ± 1.28	22.03 ± 1.71	16.08 ± 3.42	4.19 ± 1.07	10.14 ± 2.09
15	40.73 ± 1.60	41.56 ± 1.83	47.88 ± 2.16	42.77 ± 3.32	36.00 ± 2.83	25.62 ± 1.71	26.05 ± 2.76
30	55.63 ± 2.69	66.37 ± 3.52	67.18 ± 4.40	69.97 ± 2.83	71.88 ± 5.13	48.36 ± 2.21	41.66 ± 1.57
45	85.28 ± 3.57	86.56 ± 1.25	85.79 ± 2.24	84.23 ± 3.22	80.21 ± 2.90	83.92 ± 3.40	79.95 ± 3.28
60	98.83 ± 2.93	98.93 ± 2.53	98.95 ± 1.73	99.76 ± 1.67	99.68 ± 1.36	100.64 ± 2.87	98.63 ± 2.50
75	100.56 ± 2.53	100.67 ± 3.12	101.08 ± 1.70	100.31 ± 1.95	100.23 ± 1.48	101.19 ± 0.41	101.16 ± 1.67
90	101.11 ± 1.22	101.22 ± 2.13	102.03 ± 0.79	101.25 ± 1.24	101.17 ± 1.47	100.95 ± 0.68	100.92 ± 2.43

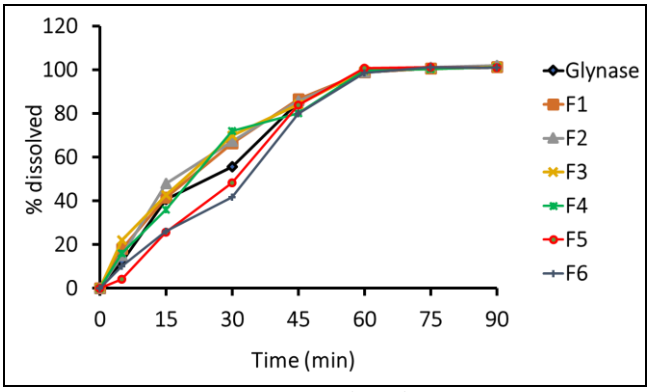

Figure 12. Comparative in vitro dissolution profiles of marketed glipizide tablets (Glynase)

CONCLUSION:

The present study successfully developed amorphous solid dispersions of glipizide using PEG 6000, PEG 8000, and Poloxamer 188 through the melting method to enhance the dissolution characteristics of the poorly water-soluble drug. Among the investigated carriers, Poloxamer 188 demonstrated the highest solubilization capacity, increasing the aqueous solubility of glipizide from 0.0345 mg/mL to 0.2562 mg/mL. The optimized glipizide–Poloxamer 188 (1:2) solid dispersion exhibited superior dissolution performance, achieving 82.70 ± 3.00% drug release within 5 min, 86.33 ± 4.39% at 15 min, and nearly complete drug release within 90 min. FTIR analysis confirmed the absence of significant drug–carrier interactions, whereas PXRD analysis demonstrated a marked reduction in drug crystallinity, indicating successful formation of the amorphous solid dispersion. The optimized formulation was

successfully incorporated into immediate-release tablets exhibiting acceptable physicochemical properties, including assay (100.26–104.78%), friability (0.523–1.011%), hardness (6.22–6.55 kg/cm²), and rapid disintegration (5.23–6.87 min). Furthermore, the optimized tablet achieved 99.76 ± 1.67% drug release within 60 min, outperforming the marketed formulation. Overall, the findings demonstrate that Poloxamer 188-based amorphous solid dispersion prepared by the melting method is an efficient and simple strategy for enhancing the solubility, dissolution rate, and immediate-release performance of glipizide, offering significant potential for improving the oral delivery of poorly water-soluble drugs.

REFERENCES:

1. Alotaibi BS, Khan MA, Ullah K, et al. Formulation and characterization of glipizide solid dosage form with enhanced solubility. *Drug Dev Ind Pharm.* 2024;50:312–24.
2. Mallick S, Mahapatra AK, Murthy PN, et al. In vivo evaluation of solid dispersion of glipizide with low viscosity grade hydroxypropyl methylcellulose. *Int J Pharm Investig.* 2023;13:145–53.
3. Ubbani RK, Tomar S. Green chemistry approach for improvement in physicochemical properties of glipizide through cocrystal formation. *Int J Pharm Sci Drug Res.* 2025;17:45–53.
4. Pavan Kumar T. Increasing the solubility of glipizide through changes in molecular structure. *Int J Pharm Sci Res.* 2024;15:211–8.
5. Mir KB, Abrol V, Singh N, et al. Spectroscopic characterization and pharmacokinetic evaluation of amorphous solid dispersions of glibenclamide for bioavailability enhancement in Wistar rats. *J Drug Deliv Sci Technol.* 2024;95:104563.
6. Yugatama A, Azizah STW, Choiri S, et al. The effect of Poloxamer 188 on the solubility and dissolution behaviors of Piroxicam-PEG 4000 solid dispersions. *Pharmacia.* 2025;72:1–9.
7. Saripilli R, Teella P, Nataraj KS. Development and characterisation of Valsartan immediate release dosage form using solubility enhancement technique. *Int J Pharm Sci Drug Res.* 2024;16:612–9.
8. Gaurang K Parmar, Shubham Singh, Sanjesh Rathi. Recent Advances in Novel Drug Delivery System for Antidepressants: Emphasis on Gastroretentive and Sustained-Release Technologies. The Bioscan 2026 Apr. 14 [cited 2026 Apr. 28];21(2):158-75.
9. Kushwah V, Succhielli C, Saraf I, et al. Amorphous solid dispersions: implication of method of preparation and physicochemical properties of API and excipients. *Int J Pharm.* 2024;665:124716.
10. Kawakami K. Roles of supersaturation and liquid–liquid phase separation for enhanced oral absorption of poorly soluble drugs from amorphous solid dispersions. *Mol Pharm.* 2025;22:1089–105.
11. Guembe-Michel N, Nguewa P, González-Gaitano G. Soluplus®-based pharmaceutical formulations: recent advances in drug delivery and biomedical applications. *Polymers.* 2025;17:463.
12. Martynek D, Ridvan L, Sivén M, et al. Stability and recrystallization of amorphous solid dispersions prepared by hot-melt extrusion and spray drying. *Pharmaceutics.* 2025;17:184.
13. Elkanayati RM, Karnik I, Uttreja P, et al. Twin screw melt granulation of Simvastatin: drug solubility and dissolution rate enhancement using polymer blends. *Int J Pharm.* 2024;660:124311.
14. Narawade GN, Panchal AB, Madankar VS, Kharade AP. Overview on emerging trends in immediate release tablet technology. *Int J Pharm Sci Rev Res.* 2025;85:1–12.
15. Waghchaude A, Jadhav G, Deshmukh S, et al. A review on formulation and evaluation of dispersible tablet for immediate release. *Int J Pharm Sci Rev Res.* 2026;88:35–44.
16. Fiftianingrum V, Sopyan I, Megantara S, et al. Recent advances in Glimepiride solubility improvement: a focus on formulation technologies – a narrative review. *Pharmaceutics.* 2026;18:84.