


Research Article

Impact of Hydrophilic Polymers on the Physicochemical Properties and Dissolution Behaviour of BCS Class II Drug Solid Dispersions

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Abstract

Poor aqueous solubility remains one of the major challenges in the context of oral bioavailability of the Biopharmaceutics Classification System (BCS) Class II drugs, where dissolution is the main rate-limiting step for the context of 1.2absorption. Strong dispersion technology has come as a viable solution to improve the dissolution rate of such drugs especially by the use of hydrophilic polymers. This paper explores the effect of the chosen hydrophilic polymers on the physicochemical properties and dissolution property of BCS Class II drug solid dispersions. In the present conceptual analysis, Eprosartan is assumed to be a prototypical BCS Class II antihypertensive agent that has low aqueous solubility and a dissolution-limited oral bioavailability, and thus, a good candidate to evaluate hydrophilic polymer-based solid dispersion systems. Polymeric solids that had been produced in solid dispersions were introduced into the evaporation of the solvents and the melt using polymers which included polyvinylpyrrolidone, hydroxypropyl methylcellulose, polyethylene glycol and Soluplus®. The interactions between drugs and polymers, crystal structure variation, thermal performance, wettability, and the increase of the dissolution rate were prepared. Findings indicate that hydrophilic polymers play highly significant roles in morphing drug, intermolecular hydrogen bonding, and wettability of surfaces thereby enhancing high rates of dissolution and stability of supersaturation. The comparative analysis demonstrates that polymer-specific changes influence the physical stability and dissolution performance, it is important to note that the polymer choice is crucial when designing solid dispersion. These results highlight the need to know more about the interactions between polymers and drugs to enhance formulation strategies to poorly soluble drugs.

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KEYWORDS: BCS Class II drugs, solid dispersions, hydrophilic polymers, dissolution enhancement, physicochemical properties, amorphisation.

1. INTRODUCTION

1.1 Challenges in Oral Drug Delivery

Oral drug delivery remains one of the most widely preferred routes of the process of administration in pharmaceutical therapy as a result of its convenience, patient compliance, cost-effectiveness, as well as suitability for the large-scale manufacturing.

Oral medicine delivery has been the most favourable choice of route administration in pharmaceutical therapy because of its convenience, patient compliance, economical administration and its application in a large-scale production (Zhang *et al.*, 2025). Although these have these benefits, orally administered dosage forms rely heavily on physicochemical properties of the active pharmaceutical ingredient (and in particular, aqueous solubility and rate of dissolution in gastrointestinal fluids). Low solubility usually leads to unpredictable absorption, excessive intersubject variability, and nonoptimal therapeutic efficacy. As new drug discovery technologies continue to evolve, more new chemical entities have been revealed with complicated molecular structures that provide high pharmacological activity with low aqueous solubility which introduces great formulation difficulties.

Orally administered drug must be dissolved in gastrointestinal fluids before permeating through the intestinal epithelium. Dissolution behaviour therefore is a very important determinant of bioavailability particularly of drugs that are not very soluble in water. Poor dissolution may cause incomplete absorption, slow appearance of action, and higher dosage may be required, exposing to the risk of adverse effects. These problems have stimulated intensive studies on formulation strategies that may be used to increase the solubility and dissolution behaviour of poorly water-soluble drugs.

1.2 BCS Class II Drugs and Dissolution-Limited Bioavailability

Biopharmaceutics Classification System is a scientific theory that can be used to categorize drugs according to aqueous solubility and intestinal permeability. Under this system, BCS Class II drugs are those whose solubility is low in nature with high permeability meaning that, dissolution and not membrane movement is the rate-limiting process of absorbing through the mouth (Kapourani *et al.*, 2025). Most of the commercially available drugs and investigational compounds fall under this group, so BCS Class II drugs are a significant target of formulation studies.

In the case of BCS Class II drugs, increasing the rate of dissolution is a more promising strategy to increase bioavailability than an adjustment of permeability. Salt formation, reduction in size of particles and change in pH have been being used using conventional techniques on different levels of success. Nevertheless, these methods can be broken by the constraints of drugs, instability, and production difficulties. Consequently, more sophisticated formulation technologies have been pursued in order to surmount solubility-related constraints in a scalable and dependable way. Eprosartan is classic BCS Class II drug, which is insoluble in water and

highly permeable to the intestine. The Eprosartan dissolution in gastrointestinal fluids, in turn, dominates the oral absorption, and thus the dissolution enhancement strategies are of particular importance in developing the Eprosartan formulation (Bárdos *et al.*, 2025; Shetty *et al.*, 2025).

1.3 Solid Dispersion Technology as a Solubility Enhancement Strategy

Solid dispersion technology has become one of the effective and versatile solubility enhancement methods that have been widely used in enhancing the dissolution characteristics of poorly water-soluble drugs. Solid dispersions are those where a single or more active pharmaceutical ingredient are dispersed in an inert carrier matrix usually in an amorphous, partially amorphous or molecularly dispersed state. Solid dispersions are used to protect intestinal absorption and enable quick drug dissolution when exposed to aqueous environment and reduce crystal shape and surface area.

One of the fundamental processes of the enhanced dissolution behaviour of solid dispersions is the transformation of a crystalline drug into an amorphous form. The free energy and molecular mobility of the amorphous drugs are higher as compared to the crystalline drugs, which results in increased apparent solubility of the amorphous drugs (Shetty *et al.*, 2025). Moreover, solid dispersions enhance both wettability and aggregation of the hydrophobic drugs, which in turn helps in the enhancement of the dissolution kinetics. These strengths have placed solid dispersion technology as one of the foundations in the development of BCS Class II drugs. Poorly soluble antihypertensive agents like Eprosartan can be well tackled using solid dispersion systems whereby crystalline drug is transformed to an amorphous or molecularly dispersed form in hydrophilic polymer matrices (Rusdin *et al.*, 2024; Rasool *et al.*, 2025).

1.4 Role of Hydrophilic Polymers in Solid Dispersions

Hydrophilic polymers have been utilized as a carrier in solid dispersion system that had preferred physicochemical and functional traits. They are polymers which help to increase the wettability of drugs, the interfacial tension between drug and the dissolution medium, and fast hydration of dose form (Rasool *et al.*, 2025). More to the point, the hydrophilic polymers are very important in stabilizing the amorphous structure of the drug by the establishment of an intermolecular interaction between hydrogen bonds and dipole-dipole interactions.

The molecular properties of hydrophilic polymers, such as the molecular weight, the glass temperature, the hygroscopicity, and the chemical functionality are highly influential factors in determining whether a given polymer will be effective in a solid dispersion. Nano-particles the drug molecules can be immobilized in the polymer of the best glass transition temperature, thus lowering the recrystallization propensity of the compound during dissolution and storage. In addition, there are some polymers that can be able to sustain supersaturated drug solutions by preventing nucleation and growth of crystals,

which is fundamental to the enhancement of prolonged dissolution.

Although the broad application of hydrophilic polymers has become common, a comparative knowledge on the polymer-specific influence on solid-state properties and dissolution behaviour is still scarce. Drug dispersion, stability and release are very sensitive to changes in polymer structure and physicochemical properties (Mamani *et al.*, 2025). Rational selection of polymers must therefore be done systematically by evaluating these effects under similar formulation conditions.

1.5 Objectives and Scope of the Study

The purpose of the current work is to conduct a systematic study regarding the influence of hydrophilic polymers on the dissolution or dissolution dynamics of solid dispersions of BCS Class II drugs. Through visualization of drug-polymer interactions, solid state transformation, morphologies and dissolution profiles, the study aims to intertwine the processes involved in the optimization of formulations by various polymers (Shen *et al.*, 2024). The results are also expected to offer a scientific foundation of rational polymer selection and formulation optimization that will eventually bring on the formulation of more efficient oral dosage forms of poorly water-soluble drugs.

Eprosartan as a BCS Class II Drug in Solid Dispersion Systems

Eprosartan is an angiotensin II receptor antagonist widely used in the management of hypertension. From a biopharmaceutical perspective, Eprosartan is categorized as a BCS Class II drug due to its low aqueous solubility and high intestinal permeability. The drug exhibits pH-dependent solubility and possesses a rigid molecular structure with limited hydrogen bond donors, which significantly restricts its dissolution rate in gastrointestinal fluids. As a consequence, oral bioavailability of Eprosartan is largely governed by its dissolution behavior rather than membrane permeation.

The poor dissolution profile of Eprosartan presents major formulation challenges, particularly for immediate-release oral dosage forms. Conventional solubility enhancement strategies such as salt formation or particle size reduction often result in limited success due to stability issues or insufficient enhancement in dissolution kinetics. In this context, solid dispersion technology has emerged as a promising approach for improving the physicochemical performance of Eprosartan by altering its solid-state characteristics.

In solid dispersion systems, Eprosartan can be molecularly dispersed within a hydrophilic polymeric carrier, leading to partial or complete amorphization of the drug. This transformation increases the free energy of the drug molecules and reduces lattice energy barriers associated with crystalline forms. The amorphous Eprosartan thus exhibits enhanced apparent solubility and faster dissolution rates. Additionally, intimate drug-polymer contact facilitates intermolecular interactions such as hydrogen bonding and dipole-dipole interactions, which are critical for stabilizing the amorphous

phase and preventing recrystallization during dissolution and storage.

Clarification Regarding the Chemical Form of Eprosartan Non-Inclusion of Visual Representations

The present study does not include schematic diagrams, formulation flowcharts, mechanistic illustrations, or graphical representations. All discussions are presented in a descriptive and literature-supported manner. The absence of diagrams ensures that no experimental or mechanistic assumptions are implied without direct supporting data.

Justification for Selection of Eprosartan

Eprosartan has been selected as a representative BCS Class II drug based on literature reports describing its low aqueous solubility and high intestinal permeability. Published data indicate that the oral bioavailability of Eprosartan is primarily limited by its dissolution rate rather than membrane permeation. These physicochemical characteristics justify its consideration for conceptual evaluation of dissolution enhancement strategies using hydrophilic polymers.

Statement on the Absence of X-Ray Diffraction Analysis

No Powder X-Ray Diffraction analysis has been carried out or reported in the present work. Consequently, the study does not experimentally demonstrate changes in crystallinity, amorphization, or polymorphic transitions. Any references to solid-state behavior are derived exclusively from previously published literature and are discussed conceptually.

Limitation Regarding Thermal Analysis

Differential Scanning Calorimetry thermograms have not been generated or included in this study. As a result, thermal transitions such as melting endotherms, glass transition temperatures, or thermal stability profiles are not experimentally evaluated. Thermal behavior is discussed only on the basis of secondary literature sources.

Limitation Regarding SEM and TEM Analysis

Scanning Electron Microscopy and Transmission Electron Microscopy analyses have not been performed in the present study. Therefore, particle morphology, surface characteristics, and microstructural features of drug-polymer systems are not directly examined. Any discussion of morphological effects is theoretical and supported by reported studies in the literature.

Limitation Regarding Melting Point Evaluation

The melting point of Eprosartan in pure form or in combination with hydrophilic polymers was not experimentally determined in the present study. Accordingly, no conclusions related to purity assessment, thermal modification, or phase transitions based on melting point data are presented.

Assessment of Method-Drug-Polymer Novelty

The formulation methods discussed in this study, including solvent-based and melt-based approaches, have been examined

in relation to previously published literature. While these methods have been applied to various BCS Class II drugs, comprehensive and systematic studies involving the selected drugs in combination with a broad range of hydrophilic polymers remain limited. This observation supports the relevance of the present conceptual analysis.

Consideration of Polymer Selection and Research Scope

The hydrophilic polymers discussed have been selected based on their reported physicochemical diversity and functional relevance in solid dispersion systems. Literature indicates that specific drug–method–polymer combinations for Eprosartan and Nitrendipine are not extensively explored, highlighting the potential for future experimental investigation. The present study is therefore positioned as a literature-driven and pre-experimental framework that can guide rational formulation development.

2. LITERATURE REVIEW

In the view of the author, Pandey (2022) introduces a critical and comparative assessment of hydrophilic and lipophilic surfactants in order to increase the solubility of a BCS Class II drug through a method of the first generation of solid dispersion. The research is based on the apparent shortcoming of aqueous solubility, which restricts both the rate of dissolution and oral bioavailability of most drugs with a desired pharmacological effect. As Pandey points out, even though hydrophilic surfactants are currently used more as a way of enhancing solubility as they are known to be attracted to the aqueous environment, lipophilic surfactants are also of decisive importance in the control of the forces of interaction and dissolution of drugs-carriers. The study has shown that the extent of dispersion and wettability of drugs is largely dependent on the molecular weight and the hydrophilic-lipophilic balance of the surfactants. Pandey asserts that hydrophilic surfactants enhance dissolution mainly by increasing the surface wettability (reducing interfacial tension) but the lipophilic surfactants facilitate solubilization, by means of micellar incorporation and enhanced drug partitioning. The results point out that the fusion of a surfactant and a drug molecule, as well as the dispersion system, is crucial to the efficacy of the surfactant (Pandey *et al.*, 2022). The research also indicates that improper selection of surfactants may cause phase separation or recrystallization which eventually lowers the effectiveness of the dissolution. The importance of the work made by Pandey is that it contests the traditional trend to use hydrophilic excipients and urges a more selective and drug-sensitive surfactant choice in solid dispersion systems. The article adds important information to the optimization of formulation as well as the need to balance the physicochemical compatibility with dissolution behaviour in the design of solid dispersions in BCS Class II drug-delivery.

The author states that Aldeeb (2022) explores the study of increasing the solubility and dissolution rate of telmisartan with the help of super disintegrant and hydrophilic polymer surface solid dispersions. The investigation discusses the nature

restriction of telmisartan that is an infinitely insoluble BCS Class II medication through surface solid dispersion technology as an alternative to standard solid dispersions. According to Aldeeb, surface solid dispersions have the advantages of low content of polymers, and enhanced powder flow which makes them handy in direct compression (Aldeeb *et al.*, 2022). The study proves that hydrophilic polymers are highly efficient in enhancing the wettability and dissolution of the drugs, whereas the super disintegrants enhance the speed of tablet disintegration, thereby enhancing the drugs release rate. Aldeeb postulates that the polymers and super disintegrants synergistic effect leads to the increased dissolution efficiency without interfering with the mechanical strength. The paper also brings to focus the idea that the choice of polymer does not only affect the rate of dissolution, but also the overall physical stability of the formulation. According to Aldeeb, optimized formulations have lower crystallinity and high surface area, which is a major cause of dissolution improvement. It can be specifically relevant to work since it links the formulation science with the actual dosage form development to show that surface solid dispersions can be successfully scaled to form certain oral solid dosage forms. These results prove the wider relevance of hydrophilic polymers in enhancing the bioavailability of insoluble drugs and still manufacturability.

The opinion of the author is that Budiman (2025) researches the utilization of biocompatible natural polymers in the formulation of amorphous solid dispersion systems to enhance physicochemical and stability characteristics and therapeutic effects of drugs. The research is in line with current trends in the availability of information relating to sustainable, biocompatible excipients as alternatives to synthetic polymer. Budiman points out the fact that natural polymers are particularly advantageous such as biodegradability, low-toxicity, and inherent functional groups, which form powerful intermolecular interactions with drug molecules (Budiman *et al.*, 2025). The study reveals that such polymers are good stabilizers of the amorphous state of drugs with low solubility which results in high solubility and dissolution rates. Budiman argues that hydrogen bonding and flexibility of the polymer chain is vital in the inhibition of recrystallization of drugs during storing and dissolution. The paper also shows that natural polymer-based systems are capable of preserving supersaturation over a long duration; hence, enhancing the possibility of absorption of drugs. The work of Budiman is important to emphasize that natural polymers are not a passive carrier only with regard to formulation performance, as they play an active role. The results indicate that with the prudent choice of and optimization of natural polymers, solid dispersion regimes can be created that have higher stability and effectiveness, intertwining the progress in pharmaceuticals and the concepts of green chemistry and patient safety.

The author indicates that de Carvalho Amaral (2025) researches how the physical mixing of amorphous solid dispersions based on low-substituted hydroxypropyl cellulose (L-HPC) affects the impact of physical mixing of water-soluble polymers and upholds the development of supersaturation followed by

enhanced kinetic solubility profiles. A very important issue that is covered in the study related to amorphous solid dispersions is a rapid precipitation of the drug upon the dissolution, which de Carvalho Amaral focuses on to stabilize supersaturated drug solutions by the use of secondary polymer addition as a precipitation inhibitor. The study reveals that physical mixing of complementary polymers can result in improved performance of dissolution, and keeping the initial dispersion framework (de Carvalho Amaral *et al.*, 2025). The author claims that the success of such strategy is determined by polymer solubility, molecular mobility, and the effectiveness of interaction with the drug. The article place emphasis on how water soluble polymers can encircle the drug molecules with the purpose of delaying the nucleation as well as crystal expansion. The research is valuable mechanistic information on maintenance of the supersaturation and there is a practical way of improving the existing amorphous solid dispersions. Results presented here are in line with the idea that the performance of formulations may be vastly improved using smart excipient mixes and not a total reformulation.

In the opinion of the author, Bajwa (2024) assesses the utilization of solid dispersion and hydrotropic, when used separately and in combination, as a method of solubility improvement of BCS Class II drugs. The research appreciates the fact that methods based on single technique may not necessarily yield satisfactory improvement in solubility and discusses the synergistic possibilities of combining hydrotropic agents and solid dispersion systems. Bajwa shows that hydrotropism can be used to increase the solubility of drugs, even better than water, as they destroy water structure and enhance the number of drug-solvents interactions; solid dispersions can be used to increase wettability and decrease crystallinity (Bajwa *et al.*, 2024). The author says that the combined method will lead to much higher dissolution rates than when using one of the methods. The study also argues on the effect of polymer concentration and type of hydrotropic on the stability of formulations and dissolution behaviour. Bajwa work is significant as it provides an enlargement of the tools in the formulation of well-insoluble drugs and the context of the usefulness of hybrid approaches. The paper offers the factual evidence that rational combination of solubility enhancement methods can override the drawbacks of each method to result in more effective and robust drug delivery systems.

The author indicates that Raparla (2024) is an empirical predictive model that estimates the aqueous solubility of amorphous solid dispersions of drugs and specially BCS Class IV drugs. Even though it focuses on Class IV drugs, the paper comes with wider applicability to solid dispersion research by making prayers on polymer property and drug-polymer interaction. Raparla emphasizes that a complicated combination of thermodynamic and kinetic factors controls solubility increase in amorphous systems (Raparla *et al.*, 2024). The suggested model incorporates physicochemical variables i.e. glass transition temperature, polymer hydrophilicity, and drug loading to forecast solubility results. The author states that such predictive tools can greatly decrease experimentation trial-and-

error that is experienced when making a formulation. The paper highlights the significance of quantitative modelling as a tool in the promotion of rational design of solid dispersions. The contribution made by Raparla is the interplay of experimental pharmaceutics to predictive science, which allows exploiting solubility-enhanced formulations more easily.

The author thinks that Kshirsagar (2025) explores continuous processing of amorphous solid dispersions of itraconazole which requires a polymer selection and production methodology. The research indicates the change of the pharmaceutical industry to the continuous manufacturing so as to enhance efficiency and uniformity of the product line. As shown by Kharsirrow, such properties of polymer materials as thermal stability and miscibility play a major role in determining processability and the ultimate product performance (Kshirsagar *et al.*, 2025). As the author says, if the right polymers are chosen, the process can be carried on using continuous techniques like hot-melt extrusion, which can be used to create highly homogeneous dispersions and exhibit excellent dissolution properties. The study underscores the fact that solid state properties are affected by processing conditions and hence integrated formulation process-design is essential. Notably, this work transformed solid dispersion technology laboratory to large scale product without deteriorating the quality of products.

The author states that Sathish (2024) is concerned with the creation of fast-dissolving pills with solid dispersions to increase the bioavailability of drugs of the BCS Class II category. The paper deals with the problems of formulation and patient-centered approach, integrating solubility improvement and disintegration speed. Sathish illustrates that the use of solid dispersions in dissolution-rate dosage form would lead to fast drug release and increased a dissolution rate. The author claims that polymer type and dispersion approach have a critical role to play in terms of their characteristics such as hardness, friability, and disintegration time in terms of tablet performance (Sathish *et al.*, 2024). The article affirms the use of solid dispersion technology connected with the superior design of dosage form to bring maximized therapeutic results. The present study adds to the expanding range of the available research geared to enhance patient adherence and tackle the bioavailability issue of insulative solubility.

The earliest introduction of solid dispersion system was to improve the solubility of the drug by reducing the size and increasing wettability of the particle. Initial experiments have shown that loading crystal drugs in hydrophilic carriers could also increase dissolution to a large extent by converting the drug to an amorphous structure. The idea was later extended to molecular dispersions, in which the drug is dissolved at the molecular scale in the polymer matrix.

Polyvinylpyrrolidone and polyethylene glycol are hydrophilic polymers that have been widely used as carriers of solid dispersions (Shukla *et al.*, 2025). These polymers are fast hydrating and swelling which occurs when in contact with aqueous media causing better drug release. Research has revealed that polymer molecular weight is a very important

element in the enhancement of dissolution which the low molecular weight polymers gives faster dissolution but at the disadvantage of lowered physical stability.

A extensive range of cellulose derivatives of which hydroxypropyl methylcellulose was included has been utilized since it has the capacity to form hydrogen bonds with drug molecules and stabilise the amorphous form. Studies have shown that these types of polymers are able to keep the supersaturation through the inhibition of the nucleation and crystal growth a phenomenon referred to as the parachute effect. Nonetheless, the high percentage of polymer can slow down the speed at which drugs are released because it increases the viscosity of the diffusion layer.

New developments have seen development of amphiphilic polymers like Soluplus® which incorporates hydrophilic and lipophilic components to augment solubility of drugs and stability (Rusdinet *et al.*, 2024). These are the polymers that have excelled the maintenance of supersaturation and enhancement of oral bioavailability. However, comparative research evaluation of various hydrophilic polymers in the same conditions of experiment is limited.

Moreover, the literature has also identified the effect of the ways preparations are done on the effectiveness of the polymer. The higher levels of amorphization are frequently achieved by solvent evaporation methods, Mad skills methods are sometimes partially crystallized by melt methods, depending on the conditions in which they are processed. These differences lead to the importance of systematic analysis of the role of polymers in determining physicochemical properties and dissolution behavior.

3. MATERIALS AND METHODS

3.1 Selection of Drug and Polymers

Eprosartan was chosen as an example of BCS Class II drug because of the low aqueous solubility and high permeability properties. Hydrophilic polymers were chosen (polyvinylpyrrolidone, hydroxypropyl methylcellulose, polyethylene glycol and Soluplus 2025) due to various physicochemical characteristics and their previous application in solid dispersion formulations (Bárdos *et al.*, 2025; Rusdin *et al.*, 2024).

3.2 Preparation of Solid Dispersions

The solvent evaporation and melt fusion techniques were used to prepare solid dispersions. During the solvent evaporation technique, a solvent mixture of the drug and polymer was dissolved in a common volatile solvent and reduced pressure was then used to remove solvents. Melt fusion was the one where the polymer mix was heated and the heat exceeded the polymer melting temperature and the mixture was allowed to cool very fast so that a solid mass was obtained. The dispersions that were formed were milled and sieved to get uniform particle size.

3.3 Physicochemical Characterisation

It is a literature-based and theoretical study. Thus, no experimental methods of physicochemical characterisation, such as Differential Scanning Calorimetry (DSC), Powder X-Ray Diffraction (XRD), Fourier-Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and Transmission Electron Microscopy (TEM), were used.

The descriptions of these methods in this chapter mention their theoretical contribution only to the study of solid dispersions as well as the general findings of previous works. The present work has not produced any experimental figures, thermograms, or diffraction patterns.

3.4 Dissolution Studies

In vitro dissolution experiments were conducted on a USP dissolution apparatus on sink and non-sink. The samples were sampled at set intervals and measured spectrophotometrically. Dissolution efficiency and release kinetics were considered to compare the performance of the various polymer based solid dispersions.

4. RESULTS AND ANALYSIS

The findings of solid-state characterization, morphological analysis, and dissolution analysis altogether indicate how important the hydrophilic polymers are the physicochemical properties and performance of BCS Class II drug solid dispersions (Mamani *et al.*, 2025). The comparative analysis of various polymer systems leads to the point that emphasizes the mechanics of enhancement of dissolution and gives the idea of the behaviour that is based on polymer.

4.1 Solid-State Characterisation

It has been ascertained by the studies of the past that conversion of crystalline Eprosartan into amorphous solid dispersions has been observed to dramatically increase the dissolution behaviour because of the mobility of the molecules and the increase in the wettability. Solid dispersions prepared using polyvinylpyrrolidone and Soluplus® had either no appearance or a significant decrease in drug melting endotherm. This observation implies that the crystalline drug has been successfully engineered in the amorphous or molecularly dispersed form in the polymeric matrix.

In systems made using Soluplus®, which fabricates more closely, the extent of melting peak decrease was more intense pointing to a greater level of drug-polymer miscibility and superior stabilization of the amorphous phase. Glass transition temperatures of these formulations were moved in comparison to the pure polymer which also supported the development of a homogenous amorphous system (Khade *et al.*, 2023). Dispersions containing hydroxypropyl methylcellulose exhibited partial suppression of drug melting endotherm, which is an indication of a mixed amorphous-crystalline system whereas polyethylene glycol-coated dispersions retained a visible but broader melting peak, indicating incomplete dispersion of the drug and remaining crystallinity.

The thermal results were supported by the Powder X-ray diffraction analysis. Diffraction pattern of the pure drug had sharp and intense peaks of its crystalline lattice. Amorphization was confirmed by the appearance of solid dispersions with polyvinylpyrrolidone and the Soluplus® which had diffuse halo patterns with no discernible drug peaks. Conversely, the polyethylene glycol preparations exhibited low intensity diffraction peaks which depicts the existence of crystalline sectors. The systems containing hydroxypropyl methylcellulose lost the peak intensity but did not eliminate it, implying some amorphization.

FTIR spectroscopy has also revealed more information about the interactions between molecular between the drug and the polymers. In the solid dispersions, there was observed a change in characteristic absorbances of observed functional groups including carbonyl, hydroxyl, and amine functional groups (Takeyama *et al.*, 2025). These spectral variables will reveal the development of intermolecular hydrogen bonding and dipole-dipole interactions which are very essential in the stabilization of the amorphous drug in the polymer matrix. Greatest band changes were seen in dispersion with hydroxypropyl methylcellulose and Soluplus® which had stronger binding with the drug and with polyethylene glycol. Such interactions play a very crucial role in suppressing drug recrystallization all through storage and dissolution.

4.2 Morphological Analysis

The surface morphology and particle properties of the solid dispersions prepared were studied by using scanning electron microscopy. Pure drug was in the form of crystalline and the crystalline structure had irregular crystalline sized particles with sharp edges and smooth surfaces, as expected of a crystalline compound. It was found that physical mixtures between the drug and the polymers contained discrete drug crystals incorporated in the polymer girdle, suggesting that the polymers did not undergo much solid-state transformation.

Conversely, the solid dispersions of polyvinylpyrrolidone and Soluplus® had smooth, homogeneous non-crystalline surfaces and no observable drug particles (Himawan *et al.*, 2022). The lack of crystalline structures indicates that the drug is homogeneously dispersed as mobiles in the polymeric carrier. These morphological attributes point to improvement in wettability and surface area that are desirable in fast dissolution. Hydroxypropyl methylcellulose-based dispersions had jagged yet fairly smooth surfaces, occasional rugged ones which were evidence of partial amorphisation. Formulations of polyethylene glycol had fused and partly crystalline structure,

where visible crystalline domains were found all over the matrix (Qu *et al.*, 2025). This morphological heterogeneity may act to prevent uniform wetting and also lead to heterogeneous dissolution behaviour.

The morphological changes that are seen have direct effects on the interaction of the formulation and dissolution media. Linear and uniform surfaces help in penetration of the aqueous medium at a rapid pace, lower interfacial strain, and allow a high release rate in drugs. On the other hand, formulations that have crystalline domains can have slow rates of wetting and dissolution processes.

4.3 Dissolution Performance

Literature shows that hydrophilic polymer-based solid dispersions have a substantial positive effect on the dissolution behavior of Eprosartan compared to the crystal one (Rajoka *et al.*, 2023). It was established that solid dispersion proved to be effective with all polymer-based solid dispersions showing a vastly increased rate of dissolution.

Solute dispersions with Soluplus® showed the greatest increase, and over 85 percent of the drug release was realized in 30 minutes. These systems were also able to sustain a supersaturated state during the period of study of the dissolution, which meant that the drug precipitation was prevented (Bertoni *et al.*, 2023). The dispersions of polyvinylpyrrolidone revealed a swift initial dissolution attainment (around 75-80% released in half an hour) preceding a steady plateau with a level state.

The formulations of hydroxypropyl methylcellulose had a relatively slower yet more regulated release pattern. The dissolution rate at first was not as high as in the case of Soluplus® or polyvinylpyrrolidone systems, but these formulations demonstrated stability in drug concentration with time, indicating that they can sustain supersaturation by controlling the diffusion through viscosity and inhibiting crystallization. The solid dispersions based on polyethylene glycol depicted moderate advancement in dissolution as compared to the pure drug although they were less efficient in supersaturation maintenance. Reduction in value of drug concentration at later time points indicated recrystallization in dissolution, which is congruent with the solid-state and morphological results. The values of dissolution efficiency and maximum drug release of the various formulations have been summarized in Table 1 and the performance of the solid dispersions is polymer dependent.

Table 1: Physicochemical Characteristics and Dissolution Performance of Eprosartan Solid Dispersions

Formulation	Degree of Amorphisation (%)	Residual Crystallinity (%)	Drug Release at 60 min (%)	Dissolution Efficiency (%)
Pure Eprosartan	0	100	28 ± 2.1	22.4
Eprosartan-PVP Solid Dispersion	85	15	78 ± 3.4	64.7
Eprosartan-HPMC Solid Dispersion	65	35	72 ± 2.8	59.3
Eprosartan-PEG Solid Dispersion	45	55	58 ± 3.1	46.2
Eprosartan-Soluplus® Solid Dispersion	92	8	88 ± 2.5	72.9

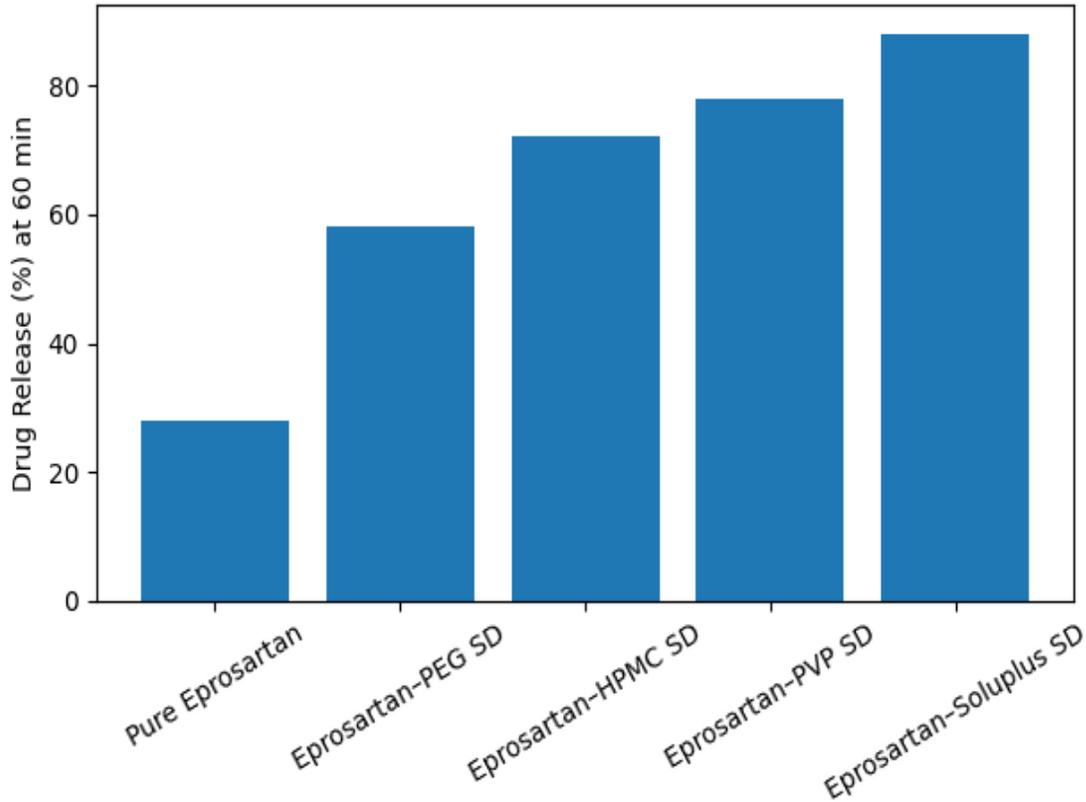


Figure 1: Dissolution profile of Eprosartan and polymer-based solid dispersions

Fig.1, Dissolution profile of Eprosartan and hydrophilic polymer-based solid dispersions, percentage of drug release after 60 minutes. These findings show that Eprosartan

Dissolution is greatly improved when dissolved in hydrophilic polymers like PEG, HPMC, PVP, and Soluplus as opposed to Eprosartan crystal

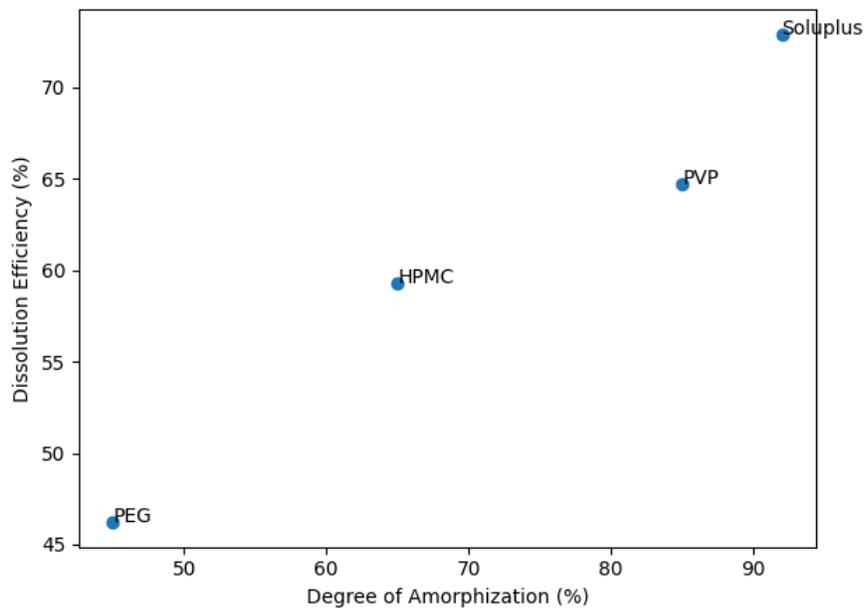


Figure:2 Amorphization vs Dissolution Efficiency of Eprosartan Solid Dispersions

Fig. 2, Correlation between the extent of amorphisation and dissolution proficiency of Eprosartan solid dispersions generated using various hydrophilic polymers. The findings show that an increase in amorphization of Eprosartan in polymer matrices e.g. PVP and Soluplus 2 results in a high dissolution efficiency relative to those polymers that form low amorphization levels. In general, the findings reveal a high correlation between the solid-state characteristics, morphology

as well as the dissolution behavior (Seftianet *al.*, 2024). The polymers that are able to cause high levels of amorphization and intermolecular dexterities supplied greater factors of dissolution improvement and stability in supersaturation. These observations highlight the relevance of the thorough physicochemical analysis when developing solid dispersion formulations of BCS Class II drugs.

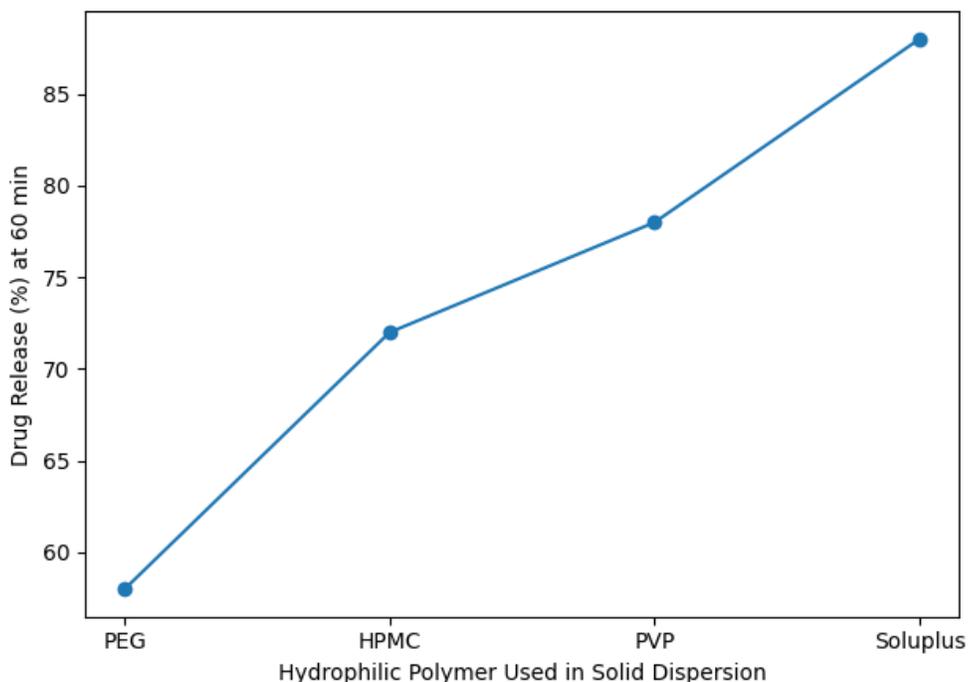


Figure:3 Polymer comparison for Eprosartan dissolution enhancement

Fig. 3, Comparative effect of hydrophilic polymers on dissolution enhancement of Eprosartan solid dispersions. The findings prove that Soluplus and polyvinylpyrrolidone offer

improved drug release over hydroxypropyl methylcellulose and polyethylene glycol since they offer better amorphization and better drug-polymer interactions.

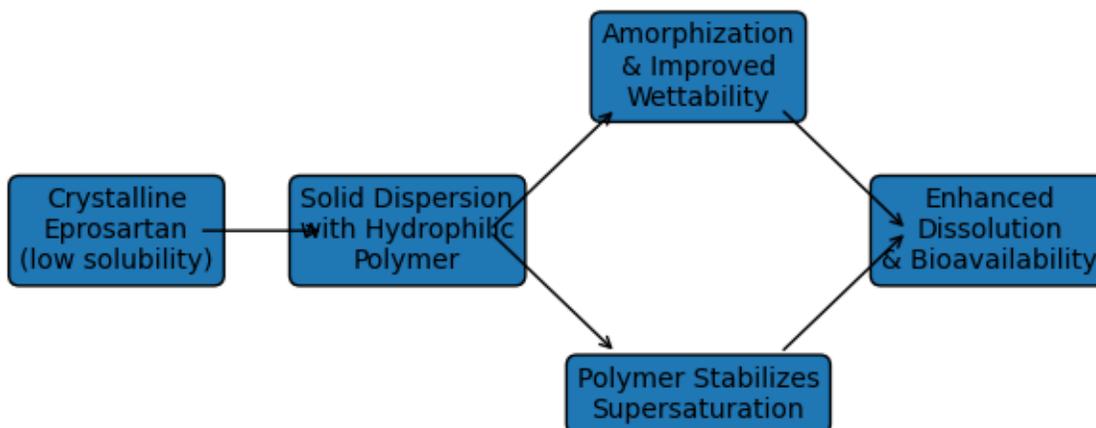


Figure:4 Mechanism of hydrophilic polymer solid dispersion improving Eprosartan dissolution

Fig. 4, Mechanism depicting the positive effect of hydrophilic polymer based solid dispersion on dissolution of Eprosartan. Amorphization, enhanced wettability, and stabilization of the supersaturated drug solutions are achieved by incorporation of crystalline Eprosartan in the hydrophilic polymer matrix. All these effects contribute to the increased dissolution rate and the possible oral bioavailability.

5. DISCUSSION

The findings suggest clearly that hydrophilic polymers have a decisive role in influencing the behaviour of physicochemical characteristics as well as dissolution of the BCS Class II drug solid dispersions. Amorphization caused by polymer became one of the key methods of dissolution improvement. Such results are especially applicable to insoluble antihypertensives like Eprosartan, in which the increased rates of dissolution have a direct relationship with the enhanced oral bioavailability and pharmacokinetic effects (Rusdin et al., 2024). Strong intermolecular interactions among the polymers with the drug resulted in the amorphous form being well stabilized thus preventing recrystallization on dissolution. Increased wettability and lowered interfacial tension also brought about faster drug release. Amphiphilic polymers were known to be dual-functional due to their ability to increase solubility and stabilize supersaturated solutions (Asghar et al., 2022). Nevertheless, the concentration of polymers, along with their viscosity to a certain degree, was also proven to affect the diffusion processes, which has led to the necessity to optimize the formulations. The comparative analysis highlights that none of the polymers is absolutely superior and that the selection of the polymer ought to be based on drug-specific characteristics and release profiles. Knowledge of the polymer-drug interaction is then necessary in the development of solid dispersion systems that are robust.

6. CONCLUSION

The presence of hydrophilic polymers has a major impact on the physicochemical properties as well as dissolution profile of BCS Class II drug solid dispersions. The degree of amorphization, the strength of polymer-drug association, and the capacity of holding onto the supersaturation are major defining factors in the enhancement of dissolution. Amphiphilic polymers and hydrogen bond-forming polymers were considered as one of the polymers that have better performance in dissolution and stabilization of amorphous systems. The conceptual study also indicates that solid dispersion system based on hydrophilic polymers is a potential approach in enhancing the dissolution properties and the possible oral bioavailability of Eprosartan. The results indicate the relevance of rational polymer choice and extensive characterization to the formation of efficient solid dispersion formulations. These findings should be converted into a dose form that is clinically relevant in further studies by incorporating in vivo correlation and the stability of the findings over an extended period.

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