Polyvinylpyrrolidone Oxime: Applications in Cosmetic and Pharmaceutical Industry Based on its Binding Properties

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Abstract

PVP has a long history of usage in both medicinal and pharmaceutical applications, and its use is showing no signs of slowing down as new advancements emerge. A water-soluble polymer derivative PVPO derived from the Polyvinylpyrrolidone is known as PVP Oxime. When used in the encapsulation and delivery of hydrophilic and lipophilic medicines (as opposed to hydrophilic and lipophilic drugs), PVPO is non-toxic and inert. It is also temperature resistant, pH stable, and biocompatible, as well as biodegradable. When it comes to controlled delivery systems, PVPO is a versatile excipient that may be employed in the formulation and development of a wide range of systems, both standard and creative. Gene delivery, orthopaedic implants, and tissue engineering are just a few examples of how PVPO can be employed in a wide variety of applications. PVPO can deliver incredible helpful capabilities with a wide range of chemical properties that are useful in a variety of applications depending on the molecular weight and modified form used. Through the use of graft copolymerization and other approaches, PVPO can be used in conjunction with poorly soluble drugs to increase bioavailability while also adding the essential swelling tract for control or continuous release. PVP has a long history of use and is rising in favour as a possible polymer for improving the character and performance of today's pharmaceutical dosage forms and so its derivatives also. Furthermore, the inquiry looks into existing patents, commercially available items, novel and prospective PVPO usage have been identified, as well as the possibility for future development, characterization, and use of PVPO in various techniques.

Introduction

The white, light, smooth, flaccid water-soluble polymer polyvinylpyrrolidone absorbs up to 40% of its weight in the water of the atmosphere. PVP is a nonionic, water-soluble polymer that rapidly dissolves alcohols, amines, acids and chlorinated hydrocarbons into polar liquids. PVP (polyvinylpyrrolidone) derivative adds extra fixative power to goods by forming a thin covering over the hair that helps keep it in the desired position (Bujak et al.). PVP aids in the dispersion of pigments, making it an excellent element for creating evenly distributed makeup. It's also a binder, which helps to keep a formula's viscosity under control.

PVPO's features as a non-irritant, non-toxic, colorless, water-soluble polymer with outstanding binding, wetting, and film-forming properties sparked attention in a range of industries and applications. PVPO is extensively used in the pharmaceutical industry as a tablet binder, disintegrant, pore forming, and solubilizer.

In the clinical chemistry community, a new magnetic drug-targeting carrier with a polymeric core–shell structure has piqued the curiosity of researchers. A wide range of materials, such as polymers and inorganic metals, have caught the interest of biochemists and chemical engineers because polymeric systems give chemical, mechanical, and thermal robustness, as well as adhesion to a variety of substrates. In addition to thin films, fibres, wave guides, and large-area structures, polymeric systems can be connected with electrical systems, and long-range orientation is feasible. Several recent advancements in nanoparticle-sized biophysical engineering have significantly increased the number of formulation alternatives available to physicians for water-insoluble medications (Bujak et al.) Using nanoparticle-mediated medicine delivery to improve bioavailability and lower chemopreventive agent toxicity, these discoveries may pave the way for the development of new treatments for cancer. It is possible that combining different types of materials can result in the development of new goods with desirable features and properties that will assist us in achieving
our objectives. When it comes to increasing medicine targeting and chemotherapy efficacy, high molecular weight polymers have been used as soluble drug carriers on a large number of occasions (KM et al., 2015). A wide range of applications for dendritic polymers as monodisperse drug carriers can be found because of their well-defined structure, multivalency, and ability to be customized by functionalization. The conjugation of drugs to polymers has been done in a variety of methods, including to increase their solubility in water, lower their toxicity owing to local drug buildup before reaching the target tissue, and protect them from enzymatic destruction or hydrolysis while still in the biological system.

Povidone's primary chemical components are carbon, hydrogen, nitrogen, and oxygen. These are the elements that make up the compound. Povidone oxime is extensively used in pharmaceuticals as a capsule and granule binder, as a film-forming agent in medical plastics, as a flavour masker in chewable tablets, and as a toxicant reduction in pharmaceuticals.

**Literature Review**

Under a 1939 patent by BASF chemist Walter Reppe, vinyl pyrrolidone reacted to the polymer that we now know as polyvinylpyrrolidone – or PVP in the presence of catalysts. Due to its remarkable affinity with colours and as a binder and thickening, this initial application data considered PVP as an additive in the textile sector.

During the 1940s, the Second World War ramped up and access to plasma blood was increasingly restricted in Germany. Burnett et al., (2017) Critically injured troops have been treated with blood plasma to maintain blood volume and reduce the risk of shock owing to low blood pressure. By the end of 1940 BASF had its first pharmaceutical use as a replacement for synthetic blood plasma, Kollidon® PVP. The application was simple: Kollidon® was used in intravenous infusions and coupled with water and inorganic salts. The higher the PVP concentration, the more effective the blood volume is. Walter Reppe and researchers from Bayer pharmaceutical laboratory patented the application in 1941.

This study uses a polyvinylpyrrolidone (PVP) dispersant known as Povidone with molecular form (C₆H₉NO)n. Povidone particle size is between 50 μm and 250 μm and the bulk density is between 400-600 g/L (Bujak et al.)

**Applications of PVP**

The synthetic polymer, which is also known as polyvidone, is a synthetic polymer via the radical polymerisation of the N-vinyl-pyrrolidone (PVP). In 1939, the German scientist Walter J. Reppe patented this technology during his research into acetylene chemistry. PVP is non-toxic, non-ionic, inert, resistant to temperature, stable in pH and biocompatible in complicated affinities with hydrophilic and hydrophobic drugs. PVP is a water-soluble polymer with varied grades of molecular weight and viscosity. PVP was used for the first time in the 1940s to enlarge the plasma volume. In the 1950s, PVP was incorporated into the hair-sprinkling industry, replacing shellac resins with hair fixing agent]. The useful role of the PVP was afterwards obtained in medicines, biomedicines, cosmetics and the food sector (KM et al., 2015). The synthesis of PVP with its specific characteristics and chemistry is advanced for the achievement of many variants such as homopolymers with varied molecular weighing, copolymers and interconnected PVP. At the outset of the commercial introduction of PVP was used as a blood plasma expander or replacer for PVP(KM et al., 2015). This subsequently found wide medical, pharmaceutical, cosmetic, food-related and industrial applications. The wide diversity of PVP uses has been already stated due to its unique functionality and its ability to interact with low molecular weight molecules. Various PVP applications can be found in (Fig:1).

The wide range of applications for PVP is mostly due to the bespoke properties that may be achieved by varying the molecular weight and polymerization. For example, the rate of dissolving is directly related to the molecular weight of PVP, but the viscosity, complexity, and adhesive power are all directly proportional to the molecular weight of PVP. Even after being biologically eliminated, PVP has a molecular weight that is inversely proportional to its molecular weight after being administered via parenteral injection. As a result, it is vital to select a certain PVP molecular weight that is appropriate for the intended use. Researchers employed a variety of PVP delivery methods, ranging from typical dose forms to controlled
release strategies. This review includes a full remark on the PVP applications in both domains, which is included in the submission.

(Fig:1) (Methods of determination of the molecular weight of PVP).

![Diagram showing methods of determination of the molecular weight of PVP](image)

<table>
<thead>
<tr>
<th>Type of representation of molecular weight</th>
<th>Method of determination</th>
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<tbody>
<tr>
<td>Weight average</td>
<td>Light scattering, ultracentrifuge</td>
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<tr>
<td>Number average</td>
<td>Osmometry, membrane filtration</td>
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pharmaceutical applications of PVP
In two main additions, lithium chloride (LiCl) and glycerol (PVDF-HFP), asymmetric micropore hollow fibre membrane, Lei shi examined the impacts of membrane shape, structure and permeability, hydrophobic and mechanical properties in which PVP was most impacted by membrane hydrophobicities. The combined effect of hydroxypropyl-β-cyclodextrin (HPβCD) and polyvinylpyrrolidone was investigated at different temperatures (PVP) (Koczkur et al, 2015).

Foltman et al., (2012) explained that the importance of PVP in forming NAP–HPβCD–PVP ternary complexes is determined by changes in thermodynamic characteristics. PVP and HPβCD have been used to produce a synergistic, more acoustic solution effect of the NAP (120 times that of the pure drug). The hollow-fiber membrane shape and microfiltration structure for the use of PVP as an additive for polyvinylidene fluoride (PVDF) has been researched, increasing reject rates and stresses. Prepared by Enrica Fontananova PVDF-polio-police hydrophobic asymmetric membranes are a phase reverse-process, in which the PVDF-police membranes provide higher resistance to mass transport because of low porosity and pore size. The PVDF-Propylene and PVDF homopolymers have been used in the reversing process. To increase the efficiency of dissolving of a pharmacological Bay Andreas Ohm[30] Andreas Ohm. The approach used in the formulation of applicable co-précipitates has been discovered to achieve super saturation with the required ratio of polyvinylpyrrolidone (PVP) to drug material, since the drug is highly sparsely soluble. The novel value biosensor and conducting copolymer molecule PVP and the co-polymer product have been produced to function as a helpful biochip with a biocompatible template. AmB
(amphotericin B) and polyvinypyrrolidone (AmB-PVP) water-soluble complexes were less hemolytic and cytotoxic than AmB in comparison to PVP-display lower cytotoxicity while maintaining antifungal efficacy. Polyvinylpyrrolidone is one of the leading excipients of modern pharmaceuticals. Combination of Ce 6-PVP imagery with spectroscopy for visual detection and discrimination between cancer and normal surrounding tissues can be widely employed. It is employed as a therapeutic agent for cancer therapy because of selective location.

(Fig.2: Adhesive applications of PVP)

(Fig:3) (As an excipient in the production of conventional dosage forms PVP has been employed in the development of several conventional dosage forms, as illustrated in Fig:3).
Tablets

There are several applications for PVP, but (Burnett et al., 2017) one that has been around for quite some time is the use of solid dosage forms (tablets, capsules, granules, and pellets). Because of its adhesive properties, PVP solution is used in the production of tablets as an effective binder in wet granulation, which can be done in either water or alcohol, or a mixture of the two (Buhler, 2005). Given the hydrolysis issue connected with effervescent pills and granules, water is not always recommended, and alcohol can be used as a substitute (Buhler, 2012). PVP is completely soluble in both of the solvents that were used to test it. In contrast, if water is to be used as a solvent for the binder in the wet granulation method or in the production of effervescent tablets, a fluidized bed granulator is recommended in order to reduce excessive contact time and hydrolysis of the binding agent in the binder solution. In a controlled setting, it has the ability to produce non-friable tablets with an ideal hardness and a consistent rate of disintegration while maintaining a consistent hardness (Buhler et al., 2012). PVP can also be used as a dry binder by mixing it with powder mixtures while they are still in their dry state, and it can be granulated on-site by mixing it with water, alcohol, or a hydroalcoholic solution to generate a granulated product while still in its dry state. Furthermore, because PVP is freely soluble in an aqueous environment such as gastric fluid, the presence of PVP as a binder has no effect on the disintegration or dissolution rate of the drug from tablets, despite the fact that it can aid in the formulation of tablets with good hardness, which is not the case with other binders such as gelatin or polyhydroxypropylmethylcellulose (PHPMC). As part of their research, (Kimaro et al.) designed chewable albendazole tablets that used the wet granulation method and PVP K30, with the purpose of accelerating the dissolution rate of the medication.

To hold the particles together, extrusion spheronization and all wet granulation modification techniques as well as fluidized bed granulation employ PVP as a binder (Buhler et al., 2005). It is possible to combine different grades of PVP with other binders due to its great compatibility with other binders, as well as to produce any specific required characteristics such as plasticity, by using PVP (Burnett et al., 2017). For example, there are formulations of antibiotics such as Rifampicin and Pyrazinamide that are effervescent, ranitidine tablets that are effervescent, ascorbic acid tablets that are effervescent, and other antibiotics that are accessible. PVP polymers were also revealed to be useful in dry granulation and direct compression techniques, which were previously unknown. In terms of tableting processes, direct compression is the quickest and most straightforward alternative out of the many available possibilities. Despite this, not all drugs have a compressibility that makes them suitable for administration by this route of administration (Burnett et al., 2017). It is being studied and applied in such a situation to use readily accessible auxiliaries that are already on the market or to create drug-binder combinations that are suitable for direct compression (Foltman et al., 2012). When used as a binder in pre-granulation forms of active substances that are intended for direct compression rather than wet granulation, PVP is particularly effective because the active substances are more vulnerable to hydrolysis when processed using the wet granulation method. Aside from that, PVP is used in the production of direct compression auxiliaries (for example, lactose granules for direct compression) as well as the granulation of active ingredients (for example, pre-granulated ascorbic acid granules with povidone) for direct compression (Burnett et al., 2017).

Oral fluids orally

PVP polymers are widely utilized as solubility enhancers for a wide range of orally soluble drugs, including diclofenac, in a variety of formulations, including oral drops, solutions, suspensions, dispersions, and emulsions (Kopolow et al., 1991). With medium to high molecular weight PVP, it is possible to create the right viscosity in the fluid form, which aids in the maintenance of a constant drip rate, the improvement of appearance, dispersion, and physical stability (acts as the thickening agent). PVP has been shown to have a flavour masking effect in formulations containing acetaminophen, trimethoprim, and sulfamethoxazole, as well as in formulations containing other medications (Login R et al., 1991). To prevent product ingredients from crystallising, PVP should be used as an inhibitor of crystal development. For example, PVP should be used in syrups that cause problems with the cap locking.

Suspensions/emulsions/dispersions

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The maker indicates that it has a variety of liquids (syrup, suspension, emulsion, dispersion, instantaneous reconstruction of granules), including suspension, dispersal, viscosity stabilisation and elevation. PVP works as the protective colloid and may effectively stabilise the suspensions, emulsions and dispersions, preventing contact, aggregation and coalescence between particles by producing a little molecular coating over the surface of the individual colloidal particles. This can also be ascribed to the hydrophilic nature gained by the individual solid particles which enables them to be separated because of steric obstructions. Given that PVP increases viscosity, the law of Stoke reduces the sedimentation rate. This increases the solution's dispersibility while simultaneously increasing the sedimentation volume. Adding PVP can boost compounds like iron oxide pigments' suspension stability as this lowers their zeta potential (Login R et al., 1991). PVP is used as binder either as a solution or as a dry powder for the creation of instant granules or dry syrup. Medium and high-molecular PVP grades are used in oral suspensions; however, a low molecular endotoxin grade is used for suspension purposes for parenteral delivery (Kurakula et al.).

Several investigations have shown that hydro-soluble polymers may leach from a coating and generate porous films, which are more permitted, or that hydrated water-filled patches can be formed inside a membrane which supports drug transport through the film. Medication releases in the formulation utilising PVP are much higher than that in which sorbitol was previously incorporated in the mix. As PVP has improved water solubility, it may be drained away readily, resulting in an increasing fluid flow rate.

**PVPO for cosmetic products**

PVPO is a water-based polymer that, due to its unique physical properties, is used as a cosmetic ingredient in hair, skin, and beauty products. Extremely high hygroscopicity qualities have been observed (Cheng et al., 2012).

- Characteristics of the film-forming process.
- Adhesiveness to a wide range of various substrates is important.
- Chelates and complexes have certain characteristics (Gebelein et al., 2012).

Because it creates a thin coating over the hair, PVPO is used in hair products to provide fixative power, as it helps to keep the hair in place while it is being styled (Kopolow et al., 1991). While serving as a binder in a composition, the usage of this ingredient in beauty and make-up products helps to preserve consistency by stimulating the dispersion of pigments, resulting in the coverage and blend effects that are desired (Cheng et al., 2012).

(Fig.4: PVP market analysis).

This derivative i.e. of PVPO product has water-soluble property which enhances its horizon of usage in cosmetics and pharmaceutics. Because they are in liquid form, they are not considered in the same way as microplastics, and the extent to which they have an impact on marine or freshwater habitats has not yet been adequately investigated. We are quite concerned about the paucity of evidence and contradicting research around their
biodegradability, and we are constantly on the hunt for any fresh information on this, as well as alternative, natural substances (Victor et al., 2012).

The binding capacity of this derivative allows it to be used in medicinal chemistry as it is water soluble and allows to get dissolve inside the body. Since its primary constituent PVP is biocompatible, it will follow the same property. (Gabelien et al., 2012).

**Conclusion**

The review explored the various applications of PVP and PVPOxime. The evaluation is by no means complete, and the use of PVP regularly develops new applications. The preceding studies show that PVP is extremely biocompatible with its derived PVP-Oxime. The interaction of PVPOxime with water is quite strong, indicating that the molecule contains open sites for binding to other molecules (Bujak et al.). In the field of pharmacogenomics, PVP or Pp-Oxime molecules are utilised in a variety of applications including thin film coatings, chemical biosensors, organic chips, medication loaders, drug delivery systems, substitutes for organic fluids, and other applications that are listed below. Anticancer agents, antihypertensive agents, immunomodulatory agents, medications, hormones, vitamins, and macromolecules, such as nucleic acids, proteins, peptides, antibodies, and other similar substances are all examples of drug kinds available (Victor et al., 2012). Controlled medications are delivered by the use of polimeric particles. The German chemist Walter Reppe initially synthesized polyvinylpyrrolidone (PVP), and a patent was submitted in 1939. Used in medicine, pharmaceutical, cosmetics and industrial production, it is still frequently applied.

Polyvinylpyrrolidone oxime is a diverse component that is utilised as binder, emulsion stabiliser, and film forming in the cosmetic and pharmaceutical sectors. It has become a desirable element because of its particular composition to ensure the preservation of quality products on the markets.

**References**


Burnett, Christina L. "PVP (polyvinylpyrrolidone)." *International journal of toxicology* 36.5_suppl2 (2017): 50S-51S.


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