EUTICALS

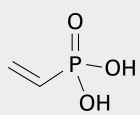
The Pharmaceutical & Fine Chemical Company

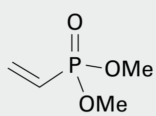
TECHNOLOGY STRENGTHS

Vinylphosphonic acid and vinylphosphonic acid dimethyl ester

Vinylphosphonic acid (VPA), its polymers and co-polymers have outstanding properties in several application areas due to the presence of both lipophilic and hydrophilic functionalities in one molecule. These products are particularly suitable for the improvement of material properties and surfaces such as coatings, corrosion inhibition and additives for dispersions.

For more than 25 years, Euticals' facilities have produced commercial quantities of vinylphosphonic acid (VPA) and vinylphosphonic acid dimethylester (VPA-DME). As the world market leader, Euticals supports its customers with the strengths and performance benefits of constantly and reproducible very high quality VPA products. Several examples demonstrate that the outstanding product properties, mainly arising from the uniquely short distance between a highly polar (phosphonic acid) and a non-polar (vinyl group) moiety, are the fundamental reasons why constantly new innovative applications are developed. VPA, its polymers and co-polymers are particularly suitable for interface applications involving interfaces. Areas of interest include surface treatment and modification, adhesion promotion and metal complexation as well as applications as dispersing agent and as flame retardant.





Characteristics at a glance:

- applicable as monomer, polymer and co-polymer
- soluble in water and most organic solvents
- adhesion promotion
- strong metal complexation properties
- dispersing benefits
- excellent heat and hydrolysis stability
- flame retardant properties

Examples of application areas

- Lithography (Printing plates, Off-set printing)
- Coating
- Oilfield Chemicals and Scale Inhibition
- Metal treatment
- Corrosion inhibitor
- Water treatment
- Dental Care
- Flame retardant
- Fuel Cells
- Pigment Dispersion
- Cement Additives
- Electro-dipcoating
- Superabsorber

Technical and scientific information

The use of colorless/odorless, water-soluble monomeric VPA and VPA-DME offers various technical and economical benefits. Both monomers can be easily polymerized/co-polymerized to products with outstanding characteristics. The high purity and quality of Euticals' VPA products ensure a high final polymer quality. The content of residual monomer for instance can be reduced to a minimum by optimizing the polymerization conditions.

One of the main effects achieved by introducing phosphorous, particularly phosphonic acid groups, into a polymer is most often an enhancement of interfacial properties. The low pKa value of VPA is responsible for a high affinity of the phosphonic acid group to metals which leads to another key characteristic of VPA – its strong metal complexation capacity. In recent years VPA-containing polymers/co-polymers have shown their potential as metal complexing and dispersion stabilizing agents in various applications. Furthermore, the high stability of the P-C-bond makes VPA stable over extreme thermal and hydrolytic conditions, and the considerable content of phosphorous (approximately 29 percent in VPA) offers interesting flame retardant properties.

Polymerization and polycondensation

VPA and VPA-DME are commonly used as versatile monomers in oligo- and polymerization as well as in co-polymerization reactions. Typically, radical polymerization is applicable at moderate conditions (25– 90 °C) using standard free radical initiators such as peroxides or azo compounds. Taking advantage of the ready solubility of VPA and VPA-DME in water and various organic solvents, polymerization conditions may be optimized to achieve tailor-made products, to reduce residual monomer content to a minimum or to synchronize conditions to existing/established processes. Suitable co-monomers are for example acrylates and styrenes. Depending on the reaction conditions (solvent, temperature, co-monomer) the molecular weight distribution ranges typically between 10-50 kDa.

The introduction of VPA in polymers/co-polymers is not limited to polymerization via vinyl functionalities. Additionally, polycondensation and co-condensation reactions with sulfonic acid derivatives may help to improve existing applications and create new products that meet markets needs.

Surface treatment

Designing and modifying surfaces is the key to success whenever two surfaces are in contact with each other. The modification usually aims either to increase or decrease the attraction of one component to the other. For example, for certain applications it is of interest to have a water-repelling or -resistant surface, whereas other usages demand for better wettability of the surface. One of the key properties of VPA is the possibility to hydrophilize or lipophilize surfaces accordingly. Using VPA is effective in low concentrations, therefore polymerized/co-polymerized products offer the opportunity to form coatings that are thinner and hence more cost effective for a variety of applications. On the other hand, the low additive content enables to minimize additive effects, and to maintain a very high level of product performance.

Due to the diverse affinity strengths of VPA to different metals, selective surface treatment or passivation is another main application field. For instance, after treatment of an Al/SiO_2 work piece with a VPA containing product, the aluminium parts are coated whereas the SiO_2 parts are available for further treatment. Typical application areas for VPA as selective surface modifiers are lithography, photography, diagnostics or medical devices.

Adhesion promotion

Addressing the challenge of connecting two different surfaces, VPA offers innovative solutions as a highly effective adhesion promoter, due to the organic/inorganic versatility of the product. VPA enables to combine the benefits of both lipophilic and hydrophilic functionalities on short distance. Thus, VPA (and its derivatives) as well as its polymers/co-polymers are particularly suitable for interfacial applications.

Moreover, VPA is prone to achieve a significant increase of adhesion between organic and inorganic layers. As a result, the manufacturers of e.g. corrosion inhibitiors, pigments, lacquers, coatings, adhesives or glass-fibers are able to reduce the content of surfactant in a formulation with no loss of strength in the coating. On the other hand, VPA-DME provides its strengths by connecting organic layers, ensuring a high performance in adhesives, plastic coatings or plastics, in electrical and electronic applications that comply to state of the art requirements as well as to certain flame retardant standards.

Metal complexation and dispersion properties

Strong metal complexation and dispersing properties complete the excellent profile of VPA. The high affinity of phosphonic acid to metal ions awards VPA and its polymers/co-polymers various special application opportunities. As a reagent in water treatment or as scale and corrosion inhibitor, e.g. in oil- and gas field chemicals, VPA helps to reduce time-consuming maintenance and repair efforts and therefore reduces total overall costs. Furthermore, any application requiring long term stability of dispersions may take advantage of VPA. As a dispersing agent, it is commonly used to improve product properties in inks and printing media, pigments or nanotechnology.

Flame retardant

Various co-polymers containing VPA units are used as flame retarding agents. As these are halogen-free, no extremely toxic secondary components such as dioxins are formed in the event of fire.

Fuel cells

In fuel cells, proton exchange membranes act as the intermediary between the spatially divided electro-chemical units. The level of energy efficiency correlates with the velocity of protons that are transfered through this membrane. By means of co-polymers containing VPA, the required high ability of proton transportation is displayed by a high level of local concentrations of acidic functionalities, respectively protons that are released and conducted through the membrane internally. VPA co-polymers are shown to act as robust, flexible and efficient proton exchange membranes in this growing field.

Further applications

VPA has found a broad spectrum of several further applications in different industries. For example, diol esterified VPA co-polymers are used as light-inducible self-hardening compositions in innovative dental ceramics and cements. Furthermore, VPA co-polymers form thixotropic gels, which can be used as thickeners for paints, printing pastes, etc. As a cement additive, VPA prevents premature loss of water and therefore prevents uneven hardening.

Fact sheet

	VPA 90 %	VPA 80 %	VPA-DME
Molecular formula	$C_2H_5O_3P$	$C_2H_5O_3P$	$C_4H_9O_3P$
CAS No.	[1746-03-8]	[1746-03-8]	[4645-32-3]
Molecular weight	108 g/mol	108 g/mol	136 g/mol
Assay	> 91.0 w/w %	> 80.0 w/w %	> 90.0 w/w %
Purity	> 97 %	> 97 %	> 97 %
Boiling point	> 250°C	– (129°F)	195°C
Melting Point (97°F)	36°C 1) (< 68°F)	< 20°C (< -22°F)	< -30°C
Density [30°C (86°F)]	1,37 g/cm^3 [30°C (86°F)]	1,37 g/cm^3 [20°C (68°F)]	1,13 g/cm^3
Shelf life 2)	1 year	1 year	1 year
Water content (Karl Fischer titration)	< 0.5 %	< 12.0 % 3)	–
Appearance pale yellow liquid or solidified melt	Colorless to pale yellow liquid	Colorless to	Colorless liquid
Hazard classification	C (corrosive)	C (corrosive)	Xn (harmful)

1) Retarded crystallization possible.
2) If stored according to MSDS.
3) Typically 8-12 %.

Specification
Vinylphosphonic acid and vinylphosphonic acid dimethylester are produced in chloride free processes and are supplied in a high quality with two different water contents.

Quality management
Vinylphosphonic acid and vinylphosphonic acid dimethylester are produced in an ISO 9001:2008 certified facility.

Registry and legal facts
Vinylphosphonic acid and vinylphosphonic acid dimethylester are pre-registered according to **REACH** (Regulation EC No 1907/2006). The products are listed in **NDSL (Canada), AICS (Australia), PICCS (Philippines), Asia-Pacific**. Vinylphosphonic acid is indexed on the **TSCA** (USA). All substances within the manufacturing process are pre-registered as well.

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