WE'VE GOT VPAs DOWN TO AN EXACT SCIENCE

VINYLPHOSPHONIC ACID AND VINYLPHOSPHONIC ACID DIMETHYLESTER

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 to improve material properties, for surfaces such as coatings, to inhibit corrosion, and as additives for dispersions.

For more than 20 years, AMRI's facilities have produced commercial quantities of vinylphosphonic acid (VPA) and vinylphosphonic acid dimethylester (VPA-DME). As the market leader, AMRI supports its customers with the strengths and performance benefits of 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 nonpolar (vinyl group) moiety — are the fundamental reasons why innovative applications are constantly developed. VPA, its polymers and co-polymers are particularly suitable for applications involving interfaces.

Areas of interest include surface treatment and modification, adhesion promotion and metal complexation as well as applications as dispersing agents and as flame retardants.

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

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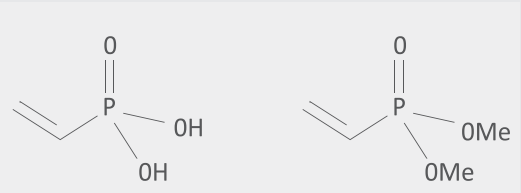
Examples of Application Areas

- Lithography (printing plates, offset printing)
- Coating
- Oilfield chemicals and scale inhibition
- Metal treatment
- Corrosion inhibitor
- Water treatment
- Dental care
- Flame retardant
- Fuel cells
- Pigment dispersion
- Cement additives
- Electro-dip coating
- 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 AMRI's VPA products ensure a high final polymer quality. The content of the residual monomer, for instance, can be reduced to a minimum by optimizing the polymerization conditions. One of the main effects achieved by introducing phosphorous into a polymer is most often an enhancement of interfacial properties. The low pKa value of VPA is responsible for the 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% 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. 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. Depending on the reaction conditions (solvent, temperature, co-monomer), the molecular weight distribution ranges typically are 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 market 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. 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 minimizes additive effects and helps 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.

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 combines the benefits of both lipophilic and hydrophilic functionalities at short distance. Thus, VPA and its polymers/co-polymers are particularly suitable for interfacial applications. Moreover, VPA can significantly increase a significant increase of adhesion between organic and inorganic layers. As a result, the manufacturers of corrosion inhibitors, pigments, lacquers, coatings, adhesives or glass-fibers are able to reduce the content of surfactants in a formulation with no loss of strength in the coating. On the other hand, VPA-DME adds strength by connecting organic layers, ensuring a high performance in adhesives, plastic coatings or plastics and in electrical and electronic applications while complying with current requirements and 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 a scale and corrosion inhibitor, 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, VPA 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 electrochemical 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.

ADDITIONAL APPLICATIONS

VPA has a broad spectrum of 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.

VPA AND VPA-DME | 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 PLATE	> 250°C	—	195°C (129°F)
MELTING POINT	36°C[1] (97°F)	< 20°C (< 68°F)	< -30°C (< -22°F)
DENSITY	1,37 G/CM^3 [30°C (86°F)]	1,37 G/CM^3 [30°C (86°F)]	1,13 G/CM^3 [20°C (68°F)]
SHELF LIFE[2]	30 MONTHS	24 MONTHS	12 MONTHS
WATER CONTENT (KARL FISCHER TITRATION)	< 0.5%	< 12.0%[3]	—
APPEARANCE	COLORLESS TO PALE YELLOW LIQUID OR SOLIDIFIED MELT	COLORLESS TO PALE YELLOW LIQUID	COLORLESS LIQUID
HAZARD CLASSIFICATION	SKIN CORR. 1B, H314	SKIN CORR. 1B, H314	ACUTE TOX. 4, H302

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

SPECIFICATION

VPA and VPA-DME are produced in chloride-free processes and are supplied in a high quality with two different water contents.

QUALITY MANAGEMENT

VPA and VPA-DME are produced in an ISO 9001:2008 certified facility.

REGISTRY AND LEGAL FACTS

VPA and VPA-DME 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).