

**ADDAPT**  
*Chemicals BV*



for tomorrow's  
Technology

**PEX<sup>TM</sup>**

Phosphate Esters



for tomorrow's

World

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# ADDAPT PEX™

## Phosphate Esters

### 1. Introduction

Phosphate esters are 100% active anionic surfactants which are produced as the free acid by either of two chemical routes. Mixtures of mono- and diesters are produced by reaction of either alcohols, alcohol ethoxylates or phenol ethoxylates with phosphorous pentoxide. Phosphate esters with a high(er) monoester content are produced by the reaction of the same feedstock with poly-phosphoric acid.

ADDAPT PEX™ anionic surfactants are mixtures of mono- and diesters which have the following general formula:



Where R- is derived from an alcohol or ethoxylated alcohol. The ratio mono- and diester is dependent on the method of production (see above).

A phosphoric ester is acidic as phosphoric acid and has similar phosphatising properties. The ionic phosphate functionality imparts antistatic properties to the molecule.

The nature of the R- group is the major factor which determines the additional properties. If this group is an auxiliary surfactant itself, such as an ethoxylate, then the detergency and wetting are greatly improved. If the group is hydrophobic then some degree of de-foaming will occur and oil solubility increased, solubility in water declines and acidity is reduced.

## 2. Product range

ADDAPT PEX™ phosphate esters are available as the free acid and in most cases as the Potassium, Sodium or Triethanolamine salt. Due to eco-toxicity problems, phenol/phenoethoxylate derived phosphate esters are not produced.

### Functional properties

Some of the useful properties are:

- Emulsification
- Solubilisation (hydrotopes)
- Corrosion inhibition
- Surface wetting
- Excellent lubrication
- Dispersant
- Anti-static
- Detergency

Product name	R-Alcohols	EO (nominal)	% P	Appearance
PEX 080B + 080Bm	2-EthylHexyl-		12 - 13 %	Pale yellow liquid
PEX 083Bm	2-EthylHexyl-	3	10 - 11 %	Pale yellow liquid
PEX 086Bm	2-EthylHexyl-	6	9 - 10 %	Pale yellow liquid
PEX 106 + 106m	C <sub>10</sub> H <sub>21</sub> -	6	4 - 5 %	Pale yellow liquid
PEX 136 + 136m	C <sub>13</sub> H <sub>27</sub> -	6	4 - 5 %	Pale yellow liquid
PEX 176*	C <sub>17</sub> H <sub>35</sub> -	6	3 - 4 %	Yellowish (semi) solid
PEX 185*	C <sub>18</sub> H <sub>37</sub> -	5	4 %	Yellowish (semi) solid

\* Laboratory/Pilot Plant product: Limited availability.

Certain products might be subject to minimum batch quantities, please refer to our local representative for further details.

## 3. Application properties

### 3.1 Emulsification - Emulsion Polymerisation

ADDAPT PEX™ phosphate esters are versatile emulsifiers. By careful selection of the R-group and neutralising agent, an emulsifier for most industrial systems can be obtained.

PEX™ 106(m), PEX™ 136(m) and PEX™ 176 are used in emulsion polymerisation to emulsify the monomer and impart stabilisation to the final polymer dispersion. A wide range of ethoxylates can be phosphated allowing greater flexibility to produce polymers with the desired end properties. By varying the mono- and diester ratio, it is possible to fine-tune the HLB value to further optimise performance. Starting point formulations are available upon request.

## 3.2 Solubilisation and Solubility

### Solubilisation

The following table provides an overview of the effectiveness of ADDAPT PEX™ phosphate esters as a solubiliser. The solubilisation property is illustrated by the cloud point in °C for each system.

Phosphate Ester	Formulation 1	Formulation 2
	5 g Alcohol Ethoxylate <sup>1</sup> 10 g TKPP 2 g PEX 83 g Water	5 g Alcohol Ethoxylate <sup>1</sup> 5 g STPP 5 g Sodium Metasilicate.5H <sub>2</sub> O 3 g PEX 82 g Water
<b>R-Alcohol</b>		
<b>PEX 080B + 080Bm</b>	76 °C	32 °C
<b>PEX 083B</b>	55 °C	45 °C
<b>PEX 086B</b>	Not determined	Not determined
<b>PEX 106 + 106m</b>	>100 °C	65 °C
<b>PEX 136 + 136m</b>	90 °C	80 °C
<b>PEX 176</b>	80 °C	90 °C
<b>PEX 185</b>	69 °C	58 °C

<sup>1</sup> Alcohol Ethoxylate (C<sub>13-15</sub> + 9 EO)

### Solubility

The solubility's of ADDAPT PEX™ range in a variety of solvents are shown in the table below.

The aqueous solubility improves with the presence of, and increased chain length of, the polyether chain. A further increase is brought about by neutralisation of the acidic phosphate group with alkali, ammonia and alkanolamines and mixtures thereof such as CODIS™ 95 (see separate brochure).

With increasing chain length the hydrophobic content gradually predominates, solubility in water declines and acidity is reduced.

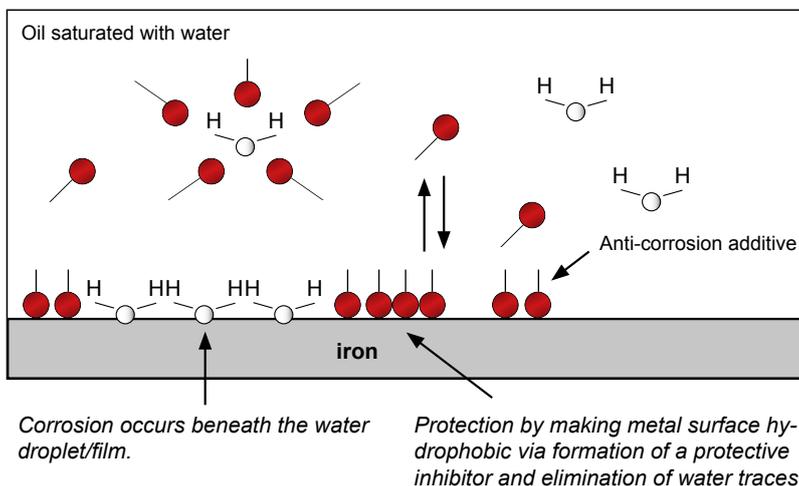
	PEX 080B(m)	PEX 086Bm	PEX 083Bm	PEX 106(m)	PEX 136(m)	PEX 176	PEX 185
<b>Solvent</b>							
<b>Water</b>	●	○	○	●	□	□ <sub>1</sub>	□ <sub>1</sub>
<b>Ethanol</b>	○	○	○	○	○	□ <sub>1</sub>	○
<b>SN 100</b>	○	●	●	□	○	□	□
<b>Mineral oil</b>	○	●	●	□	○	□	□
<b>Oleyl Alcohol</b>	○	□	□	○	○	□	●
<b>White spirit</b>	○	●	□	○	○	□	□
<b>Caster oil</b>	○	□	○	○	○	□	□
<b>Rapeseed oil</b>	○	□	□	□	○	□	□
<b>Hydrocarbons (aliphatic)</b>	○	●	●	□	○	□	□

○ = Soluble □ = Part soluble ● = Insoluble 1 = Gelled/thickened

### 3.3 Corrosion inhibition, de-rusting, lime scale removal

#### Corrosion inhibition

Small amounts of water are inevitably present in protective systems like Coatings and Lubricants. This may arise from contamination, (oil) degradation or condensation. If this water is not suppressed it will be adsorbed onto metal, in particular iron surfaces. When oxygen is present, a localised electrochemical cell is created between the metal (anode) and its oxide layer (cathode) which results in corrosion. Metal incorporated into the oil via this process is a potent oxidation catalyst. In order to inhibit this, anti-corrosion additives may be added. These contain a polar group enabling them to strongly adhere to the metal surface and a long alkyl chain that will repel water and oxygen.



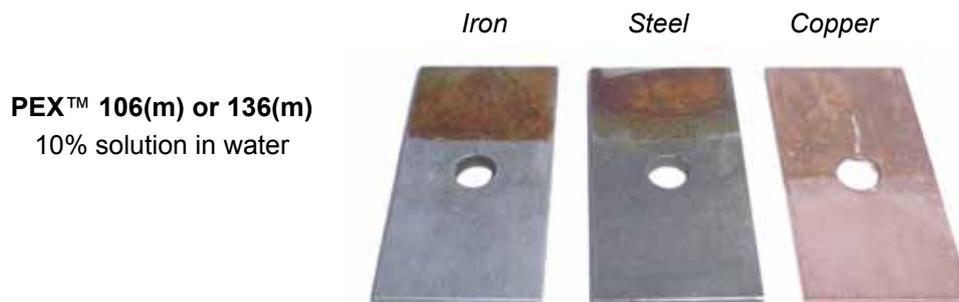
Alkali, Metal or Alkanolamine salts of ADDAPT PEX™ are suggested as corrosion inhibitors for (multi) metal protection. ADDAPT Chemicals offers a comprehensive range of formulated corrosion inhibitors for this purpose.

ADDAPT Chemicals' corrosion inhibitors provide excellent performance at low concentrations for ferrous and non-ferrous substrates. Added benefits afforded by the ADDAPT range include good biostability and boron free products for environmental sensitive applications in combination with cost-effective performance.

#### De-rusting

A phosphoric ester is acidic as phosphoric acid and has similar phosphatising properties without the corrosivity of phosphoric acid. They are effective in acid pickling and degreasing agents for de-rusting and degreasing for industrial metal cleaning.

The picture below illustrates the de-rusting power of a 10% solution in water of ADDAPT PEX™ phosphate esters without formulation optimisation.



Depending on the alcohol/alcohol ethoxylates chain, solubility in oil or water can be achieved.

Both PEX™ 083Bm, PEX™ 106(m) and PEX™ 136(m) are effective corrosion inhibitors for neutral and alkaline aqueous systems.

PEX™ 080B(m) is recommended for oil/solvent based systems where it imparts de-rusting properties with excellent 'build-in' corrosion inhibition. It gives excellent protection of Zn, Pb and Sn-surfaces. It prevents formation of Pb-soaps.

### Lime scale removal/Scale inhibition

Removing lime scale or rust is a major problem in many fields of application. Strong acids remove such deposits easily but they also attack and damage the surface; iron and steel in particular as well as aluminium alloys are attacked severely by inorganic and organic acids. Also plastics, glass and ceramic surfaces are corroded by strong chemicals.

The corrosivity of these acids in aqueous solutions can be greatly reduced or even completely eliminated by phosphate esters.

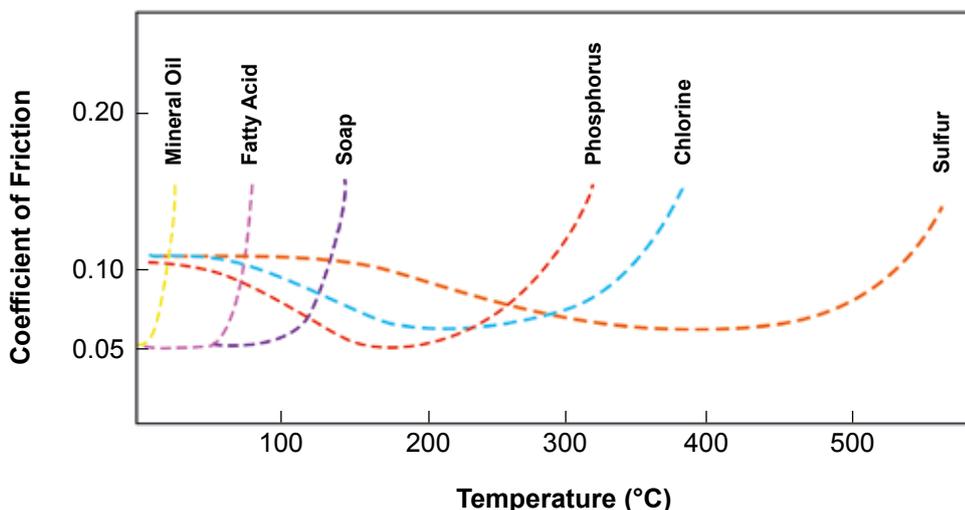
Both PEX™ 080B(m) and PEX™ 106(m) are broadly used as scale inhibitors showing enhanced corrosion inhibition (see Technical Data Sheet: PEX™ 080B-SI and PEX™ 106-SI).

## 3.4 Metalworking products

The Emulsification, Corrosion inhibition and Anti-Wear/Extreme Pressure properties in both aqueous and non-aqueous systems provided by the PEX™ phosphate esters are employed in application areas such as:

- Metal cutting and grinding fluids
- Synthetic and semi synthetic cutting fluids
- Rolling oils
- Hydraulic oils
- Lubricating oils
- Rust preventatives and pre-lubes

Anti-Wear/Extreme Pressure (EP) additives are organic components containing elements like Cl, S and P that resist high temperatures (see illustration below). These elements react with the metal surface to form a protective film and reduce friction. Examples are: Sulfurised Oils, Chlorinated Paraffins and Phosphate esters.



The proper choice of PEX™ phosphate ester offers an environmentally safe alternative to Cl-paraffins. They can be used in all Metal Working Fluids:

- Straight oils
- Soluble oils and Semi-Synthetic
- Synthetic (true water solutions)

The PEX™-salts (especially those with CODIS™ 95) are selected to give the optimum results for any one application. Products like PEX™ 185 have been shown to possess excellent anti-wear, anti-corrosion, lubricity and EP properties.

For general purpose synthetic cutting and cooling fluids, 10 - 15% of the CODIS™ 95 salt of PEX™ 136(m) is recommended. The inclusion of CODIS™ 95 improves solubility, wetting and anti-corrosion properties.

PEX™ grades like PEX™ 080B(m), PEX™ 083Bm and PEX™ 086Bm with shorter alkyl chain are recommended for aqueous based grinding fluids. They show superior wetting and detergent properties, aiding the wetting of the wheel and work surface.

Oil lubricants can be formulated by inclusion of PEX™ 080B(m) or sometimes PEX™ 083Bm at approximately 2 - 5% depending on their application. The amine salts are suggested as corrosion inhibitors in lubricating oils, whilst their EP and anti-wear properties are also of value in engine oils.

In rolling and drawing oils, PEX™ phosphate esters function as corrosion inhibitors, emulsifiers and EP additives. They are often combined with non-ionic surfactants to give optimum emulsion characteristics.

### 3.5 Textile and Leather; antistatic

#### Textile

Phosphate esters are the preferred surfactants for textile and leather processing fluids because of their anionic, wetting, low foaming, alkaline tolerance and building/hydrotopic properties. In addition, their performance as emulsifying, lubricating, softening and antistatic agent offers the formulator a multifunctional ingredient.

PEX™ 080B(m), PEX™ 083Bm and PEX™ 136(m) are recommended as wetting and antistatic agent for textile finishes leaving an anti-corrosive film on the machinery during processing. Longer chain PEX™ grades also provide a softening effect on many yarns and fibres. Concentrations of 0.25 - 0.75% of the phosphate are recommended.

The compatibility of the PEX™ grades with mineral oil in alkali systems allows their use as emulsifiers for textile lubricants.

#### Leather

Due to their multifunctional properties of emulsification, PEX™ grades can be employed in fat liquoring blends for the treatment of wet leather. Fat liquors, which are typically oil in water emulsions, replace natural oils and lubricants removed in previous processing steps and improve the softness, flexibility and tensile strength of the leather. PEX™ 176 is recommended as a component in leather processing chemicals.

### 3.6 Agrochemical additives

Phosphate esters are excellent wetting agents, emulsifiers and dispersants in agrochemical concentrates. Combined with non-ionic surfactants they are alternatives to aromatic sulphonates such as alkyl benzene sulphonate and naphthalene sulphonate to prepare very stable micro-emulsions.

Many agricultural adjuncts such as herbicides and pesticides are required in water solution for application to foliage. Phosphate esters are ideal for emulsification/solubilisation of additives in water together with excellent wetting to ensure optimum spreading onto the leaf's surface.

### 3.7 Oil field Chemicals

Phosphate esters possess outstanding load carrying and corrosion inhibition properties which makes them ideal for oil and transport applications. Phosphate esters are often used as amine/amido – amine salts to enhance their corrosion inhibition properties. PEX™ 136(m) in its amine neutralised form is recommended for oil field applications.

### 3.8 Home Care and I&I

The most widespread application for phosphate esters is in Home Care and I&I industries where the excellent detergency, wetting, antistatic and solubilisation properties are useful in application such as:

- Hard surface & Metal cleaners
- Bottle washing compounds
- Household detergents
- Wall/Floor/Tile/Glass cleaners
- Heavy duty liquid and acid cleaners
- Laundry Detergents
- Dish and Glass rinsing
- Electrolytic cleaners
- Paint/Wax strippers

ADDAPT PEX™ phosphate esters are useful emulsifiers for the formulation of hard surface, metal and heavy duty cleaners, solvent based degreasers and window cleaners. Due to their high alkali tolerance, PEX™ phosphate esters are compatible with many alkali builders.

The ADDAPT PEX™ products also possess hydrotoping properties which assist in the formulation of alkaline cleaners, oven cleaners and floor/wax strippers. They function as coupling agents/ hydrotopes for non-ionic surfactants which may be included in the cleaning system to enhance degreasing properties.

Phosphate esters are widely used in the formulation of rinsing aids for automated dish and glass washing systems. To raise the cloud point, low foaming hydrotoping phosphate esters like PEX™ 106(m) can be used in combination with biodegradable EO/PO derivatives which often possess low cloud points and poor solubility.

Phosphate esters like PEX™ 106(m), PEX™ 080B(m) and PEX™ 083Bm and neutralised versions thereof offer greatly enhanced dirt removing properties and wetting and corrosion inhibiting properties.

Phosphate esters like PEX™ 106(m) and PEX™ 083Bm are particularly useful in acid cleaning systems for aluminium and stainless steel where the removal of deposits of iron oxide in combination with oil and grease (trains/trams) is difficult to overcome with neutral cleaners.

Phosphate esters like PEX™ 106(m) and PEX™ 083Bm vastly reduce corrosion effect in phosphoric acid based cleaners.

Phosphate esters are also excellently suitable for light duty cleaners for metal fittings for lime scale removal.

#### **Antistatic**

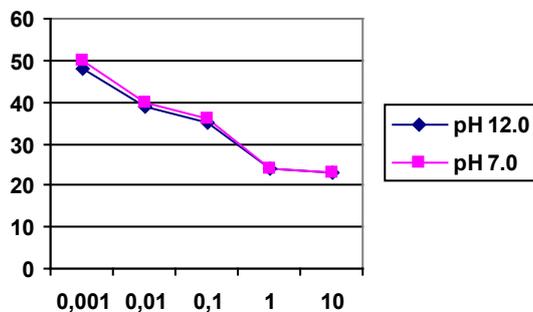
Due to antistatic properties, for Home Care cleaners and polishes, PEX™ phosphate esters reduce dust attraction/re-soiling onto modern household surfaces.

## Wetting

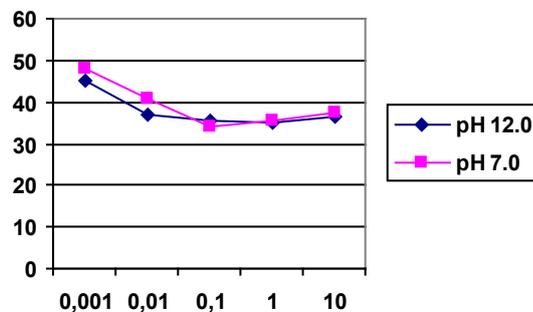
PEX™ phosphate esters are excellent wetting agents. Low surface tensions can be obtained as shown in the graphs below. Lower surface tensions can be obtained by neutralising the phosphate esters with alkali metal hydroxides or alkanolamines. At elevated temperatures, PEX™ phosphate esters are more efficient wetting agents than the parent alcohol/alcohol ethoxylates and are less affected by electrolytes.

### Wetting performance phosphated alcohols

**PEX 080B**

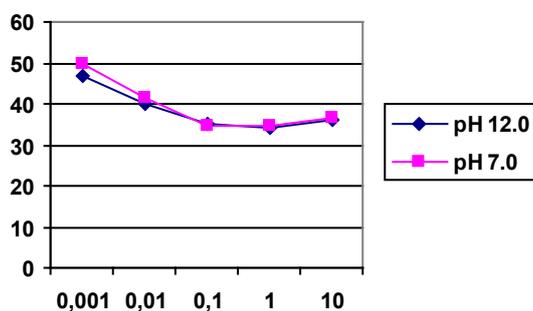


**PEX 083B**

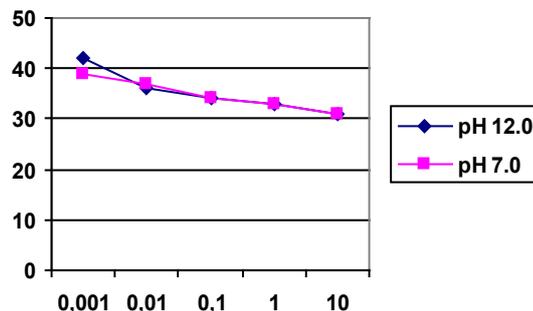


### Wetting performance phosphated alcohol ethoxylates

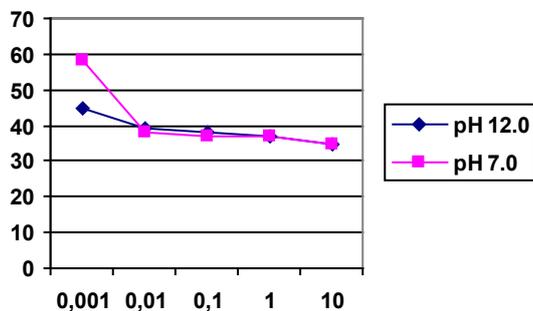
**PEX 086B**



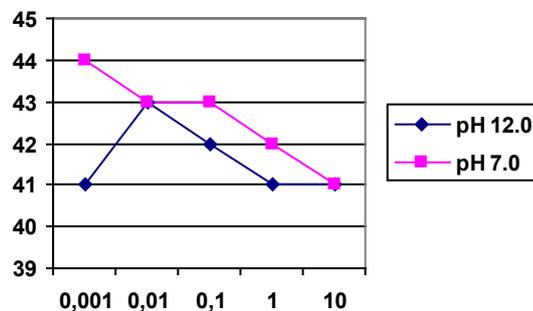
**PEX 106**



**PEX 136**



**PEX 176**



**Note:** x-axis = concentration / y-axis = Static Surface tension-Dynes.cm-2

## 4. Biodegradability/Eco-toxicity

**ADDAPT PEX™ phosphate esters are:**

- Inherently biodegradable
- Considered to be non eco-toxic
- WGK 1 classified

*Starting point formulations are available upon request. These formulations are suggested for formulators to add their own ideas and experience in producing their finished products. They are offered in good faith and without warranty.*

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