

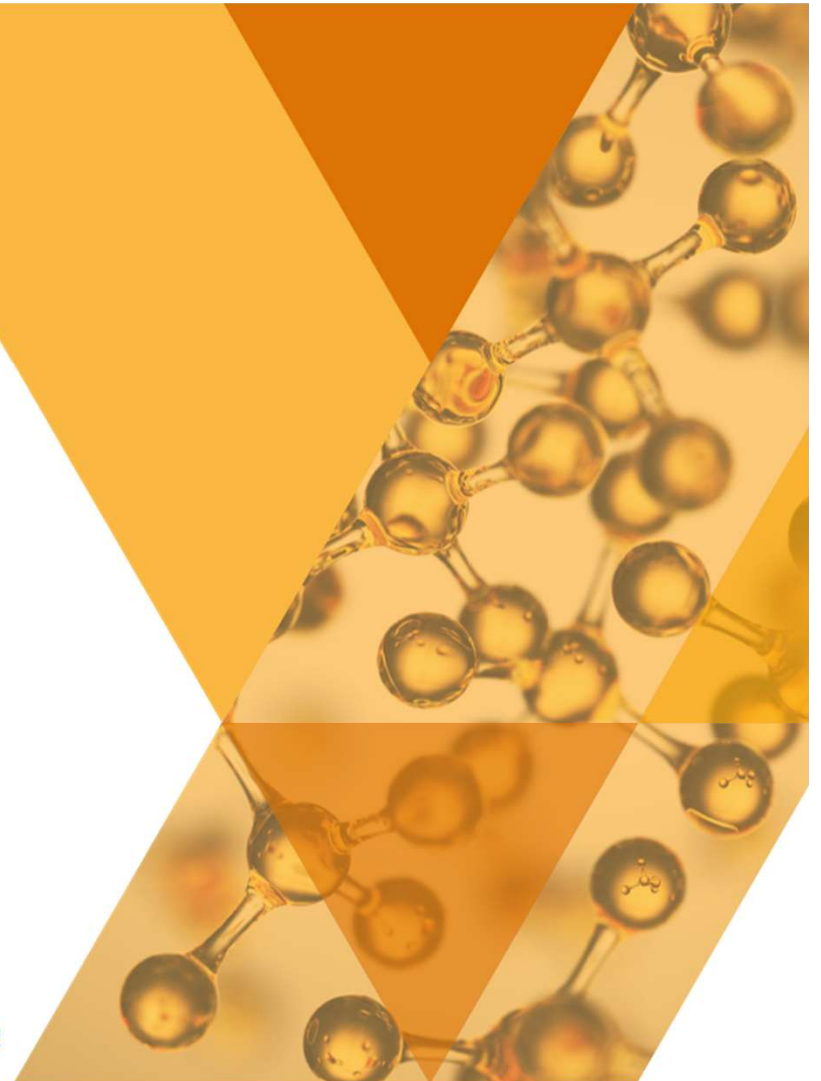
Zschimmer & Schwarz

LUBRICANTS

lexolube
synthetic esters

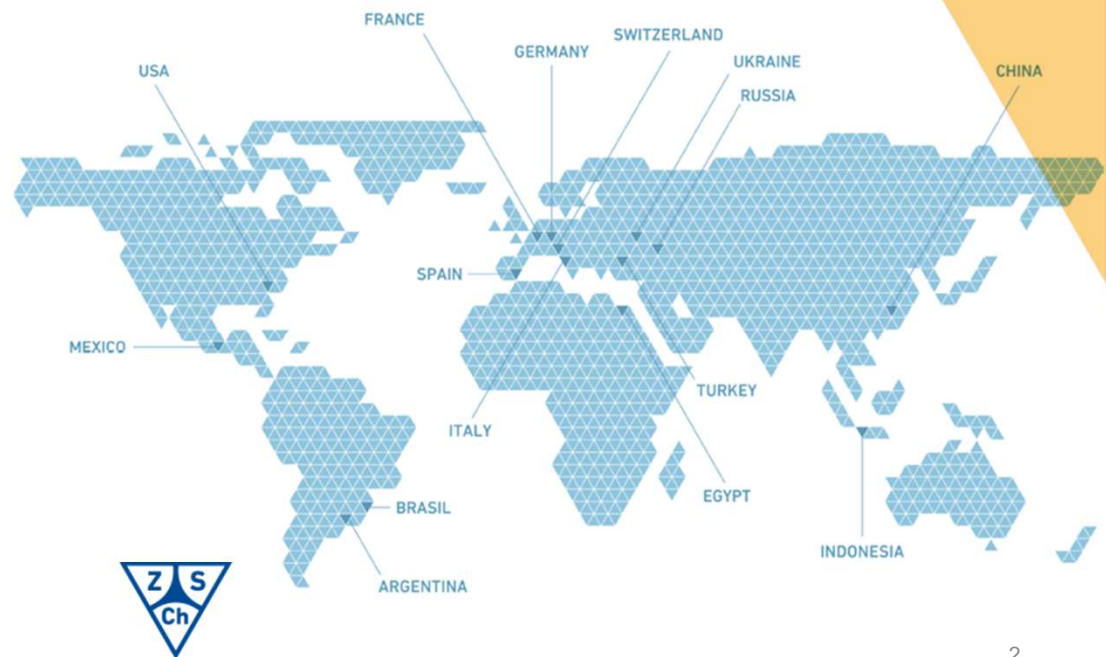


ZSCHIMMER & SCHWARZ



Zschimmer & Schwarz today

- ▶ HQ in Lahnstein, Germany
- ▶ Global manufacturer of tailor made chemical solutions
- ▶ 9 product divisions
- ▶ 16 countries, 30 subsidiaries
- ▶ more than 1,400 employees
- ▶ € 600 million (~\$700M) group revenue in 2020



Business divisions

- ▶ Lubricants
- ▶ Paints & Coatings
- ▶ Personal Care
- ▶ Industrial Specialities
- ▶ Fibre Auxiliaries
- ▶ Textile Auxiliaries
- ▶ Leather Auxiliaries
- ▶ Ceramic Auxiliaries
- ▶ Cleaning Specialities

Lubricants



Fields of application for our products

- ▶ Hydraulic fluids
- ▶ Oven chain oils
- ▶ Grease
- ▶ Compressor fluids
- ▶ Transformer oils
- ▶ Metalworking fluids
- ▶ Environmentally sensitive applications
- ▶ Engine oils
- ▶ Transmission fluids
- ▶ Gear oils
- ▶ Aviation turbine oils
- ▶ Drilling mud lubricants
- ▶ Food processing H1 lubricants



Lubricants





Lubricants

MANUFACTURING SITES

Lubricants division manufacturing

- ▶ ZS manufacturing Synthetic Esters in Milledgeville, GA since 2005
- ▶ ZS manufacturing Synthetic Esters in Tricerro, Italy since 2016
- ▶ LEXOLUBE® line acquired from Inolex in January 2017
- ▶ ZS Ivey, Georgia, USA Ester plant opened in 2019
- ▶ LEXOLUBE® and LUBRICIT portfolio now manufactured in Italy and two sites in the USA
- ▶ ZS also manufactures alkoxyate esters, phosphate esters, phosphonates, amides, and other auxiliary ingredients in multiple locations around the globe



New manufacturing site

- ▶ Ivey, Georgia, USA
- ▶ Greenfield location near Atlanta, Georgia
- ▶ Built to manufacture advanced lubricant grade synthetic esters
- ▶ Multiple reactors support our broad Synthetic Ester product line and commitment to tailor-made products
- ▶ Modular design to integrate additional capacity quickly
- ▶ Commissioned in January 2019

Lubricants



Ivey manufacturing – QEC process

- ▶ Quality, Efficiency, Consistency
- ▶ Equipment designed for challenging, lubricant grade Synthetic Esters
- ▶ Accurate charging and temperature control for fast cycles
- ▶ Reduced losses in evaporation, filtration
- ▶ Less waste to process
- ▶ Significant efficiency improvement
- ▶ Automated process control leads to lower product variability



Z&S Italiana – Tricerro Technologies

- ▶ Sulfation
- ▶ Sulfonation
- ▶ Amidation
- ▶ Quaternarization
- ▶ Compounding & Blending
- ▶ **Esterification**
 - New production line built in 2016
 - Dedicated vessels for finishing/refining
 - On-line process control testing



Manufacturing synthetic esters to optimize performance

▶ QUALITY RAW MATERIALS

- Food safety standards
 - Select products are also Kosher/Halal
- Color, odor, viscosity, etc.

▶ ACCURATE REACTOR CHARGING

- Efficient use of raw materials
- Short cycle times
- Viscosity control
- Product consistency

▶ ESTERIFICATION KNOW-HOW

- Low acid value
- Low water content
- Tight specifications
- Filtration

▶ FORMULATED FLUIDS

- Blending
- Additive treatment
- Drumming and Private labelling



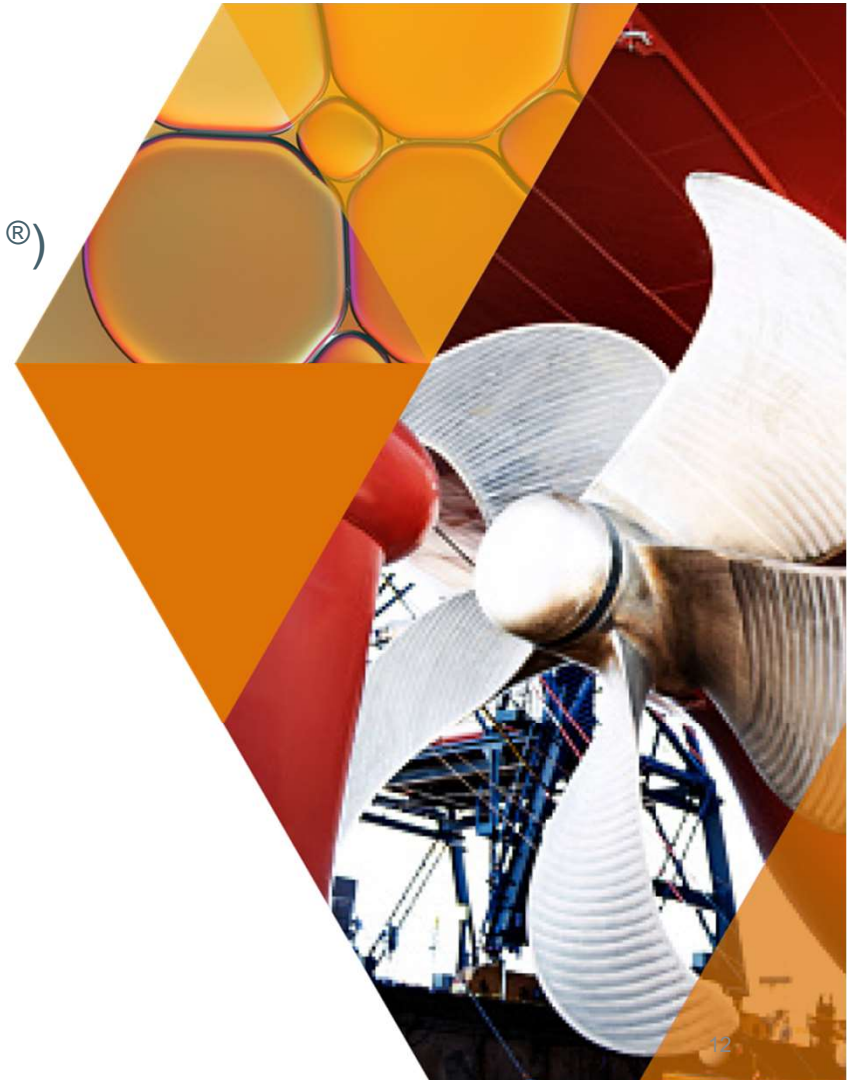


Lubricants

PRODUCT OVERVIEW

Product overview

- ▶ Synthetic Esters (LEXOLUBE[®], LUBRICIT[®])
- ▶ PEG/PPG Esters (MULSIFAN[®])
- ▶ Phosphate Esters (PHOSPHETAL[™])
- ▶ Phosphonates (CUBLEN[®])
- ▶ Amides (PURTON[®])



Performance characteristics

▶ SYNTHETIC ESTER BASE OILS

- Boundary lubrication
- Thermal and oxidative stability
- Low volatility/high flash point
- Wide temperature performance
- Low sludge or deposit formation
- Energy efficient
- Biodegradable
- Environmentally and worker friendly

▶ ALKOXYLATE ESTERS (PEG/PPG)

- Non-ionic emulsifiers
- Hard water stable
- Boundary lubrication

▶ PHOSPHATE ESTERS & AMIDES

- Emulsifier/Co-emulsifiers
- Corrosion inhibitors
- Non-staining



Synthetic ester summary

- ▶ Z&S esters are tailor-made to meet the requirements of the formulator
- ▶ Multi-functional performance
 - Lubricity
 - Extreme temperature performance
 - Extended drain intervals
 - Clean operation
 - Low volatility
 - High VI for fluid energy efficiency
- ▶ Used in automotive and industrial lubricant formulations that outperform mineral oil products
- ▶ Excellent environmental safety and toxicological profile
- ▶ Incidental food contact (NSF HX-1) grades available





Lubricants

ESTER CHEMISTRY

DESIGN OPTIONS

Lubricant Synthetic Ester types

- ▶ Mono Esters
- ▶ Diesters
- ▶ Polyol Esters
- ▶ Complex Esters
- ▶ Aromatic Esters
- ▶ Food Grade (NSF H1) Formulated Fluids
- ▶ Food Grade (NSF HX-1) Base Stocks and Additives



Monoesters

- ▶ Typically made from natural fatty acids and mono-alcohols
- ▶ 60-90% renewable
- ▶ Low viscosity
- ▶ Excellent lubricity
- ▶ Low odor and color
- ▶ Environmentally and worker friendly
- ▶ Can be designed for excellent hydrolytic stability
- ▶ Biodegradable



▶ FIELDS OF APPLICATION

- Metalworking
- Textile lubricants
- Aerosol products
- Adjuvants
- Oil field drilling mud
- Biobased lubricants
- HX1 grades available



Diesters

- ▶ Typically made from dibasic acid and mono-alcohol
- ▶ Not usually bio-based
- ▶ Low to medium viscosity
- ▶ Excellent lubricity
- ▶ Very low pour point
- ▶ Excellent oxidative stability
- ▶ Low odor and color
- ▶ Biodegradable



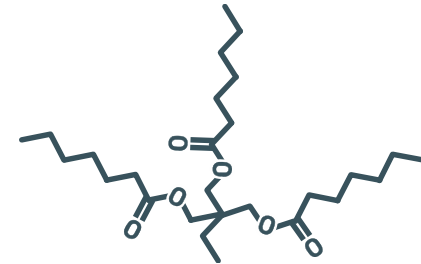
▶ FIELDS OF APPLICATION

- Engine oils
- Compressor oils
- Hydraulic fluids
- Gear oils
- Grease
- Bearings
- Seal swell additives



Polyol esters

- ▶ Made from neo-polyol and mono-acid
- ▶ Can be bio-based
- ▶ Low to high viscosity
- ▶ Low volatility / High flash point
- ▶ Low pour point
- ▶ Long drain intervals
- ▶ Outstanding oxidative stability
- ▶ Can be biodegradable



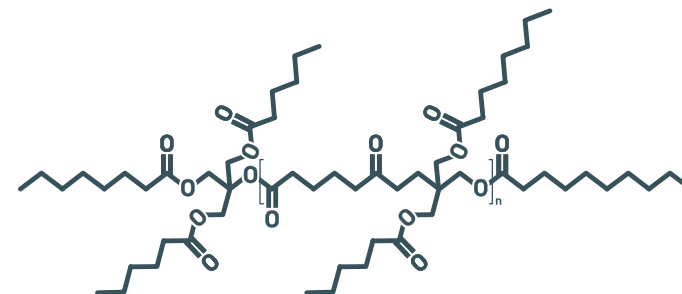
► FIELDS OF APPLICATION

- Compressor oils
- Fire resistant hydraulic fluids
- Oven chain oils
- Aviation turbine engine oils
- Gear oils
- Engine oils
- Grease
- HX-1 products available



Complex esters

- ▶ Capped polymeric ester
- ▶ Can be bio-based
- ▶ Very high viscosity possible
- ▶ Low volatility/High flash point
- ▶ High viscosity index
- ▶ Antiwear/Extreme pressure
- ▶ Can be biodegradable



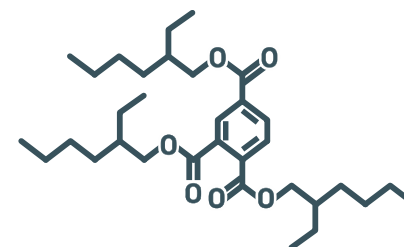
▶ FIELDS OF APPLICATION

- Compressor oils
- Gear oils
- Grease
- Thickening
- Metal protection
- HX-1 products available



Aromatic esters

- ▶ Made from aromatic anhydrides and mono-alcohols
- ▶ Not bio-based
- ▶ High viscosity
- ▶ Low viscosity index
- ▶ Low volatility / High flash point
- ▶ Reduced varnish
- ▶ Stable against oxidation & hydrolysis
- ▶ Long fluid life



▶ FIELDS OF APPLICATION

- Compressor oils
- Gear oils
- Grease
- Oven chain lubricants
- Plasticizers





Lubricants

BENEFITS OF SYNTHETIC ESTERS

Synthetic Ester Design Considerations

- ▶ Determine critical application performance requirements
 - Low cost – Oleates, natural fatty acids, commodity raw materials
 - High viscosity – Dipentaerythritol, complex esters
 - High viscosity index – Linear structures, long chain fatty acids
 - Thermal stability – Polyols, branched acids, fully saturated components
 - Biodegradability – Natural fatty acids, less branching
 - Food contact – Ingredients with detailed information on toxicity, NSF listed

- ▶ Build the ester from components that will give the desired properties



Esters as base oil blend components reduce deposits and sludge

► BLENDS OF PAO AND POE

- All fluids were ISO 68
- Tested 20 hours at 260°C

► RESULTS

- 6-7% evaporation for all samples
- 5% POE significantly reduces deposits



Hydraulic fluids

- ▶ Synthetic Esters provide excellent thermal and oxidative stability
- ▶ Low sludge formation
- ▶ Fire resistance („Less Hazardous“ HFDU fluids)
- ▶ Low volatility
- ▶ Very low compressibility
- ▶ High VI provides improved energy efficiency
- ▶ Typical viscosity grades – ISO 32, 46, 68
- ▶ Good lubricity

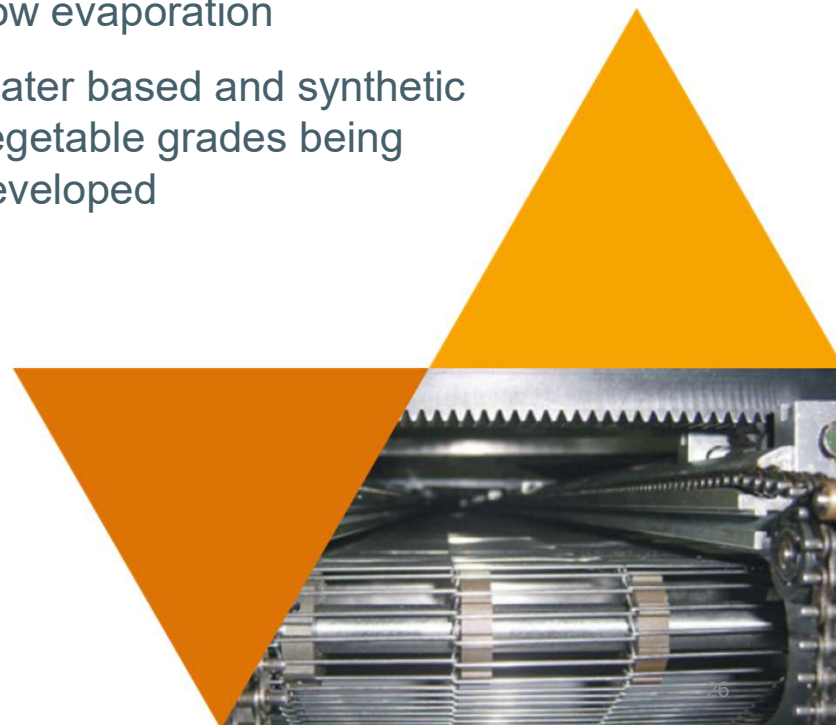
Lubricants



Oven chain oils

- ▶ Synthetic Esters provide excellent thermal and oxidative stability
- ▶ Typical formulation (ISO 68-460)
 - 97% synthetic ester, 3% additives
- ▶ Polyol esters – up to 275°C
 - Best oxidative stability, very clean, low varnish
- ▶ Aromatic esters – up to 250°C
 - Higher evaporation, softer deposits

- ▶ Complex esters – up to 225°C
 - Better lubricity and antiwear, low evaporation
- ▶ Water based and synthetic vegetable grades being developed



Grease

- ▶ Synthetic Esters allow wide temperature range performance
- ▶ Typically requires non-soap thickener (urea, silica, etc.)
- ▶ Polyol esters: up to 240°C
 - Best oxidative stability, very clean, low varnish
- ▶ Arctic grease: down to -60°C
 - Low viscosity diester or polyol ester
- ▶ Bio-based esters: -20 to +175°C
 - Excellent lubricity
 - Recommended for environmentally sensitive areas



Compressor Oils

- ▶ Synthetic Esters offer deposit control and long fluid life
- ▶ Excellent solubility/compatibility with HFC refrigerants
- ▶ POE used in combination with PAO or Group III MO
- ▶ Reciprocating and rotary vane compressors
 - Diesters and Aromatic esters for lubricity and solvency
- ▶ Rotary screw and centrifugal compressors
 - Polyol esters for oxidation stability
- ▶ NSF HX-1 Polyol esters
 - For compressors in food processing plants



Synthetic electrical transformer oils

- ▶ High flash and fire point
- ▶ Good thermal stability for long life
- ▶ Low viscosity with low volatility
- ▶ Good dielectric properties
- ▶ Compliant with IEC 61099
- ▶ Environmentally friendly
- ▶ Bio-based esters offer improvement over vegetable oils and mineral oils



Automotive applications

- ▶ Synthetic Esters have a long history of high performance in racing oils and premium synthetics
- ▶ Full synthetic oils typically utilize a combination of PAO and POE
- ▶ Diesters improve additive solubility
- ▶ Low viscosity trend (0W-20 and lower)
- ▶ Low NOACK volatility
- ▶ Clean, reduces sludge formation
- ▶ Long drain intervals



Environmentally acceptable lubricants (EAL)

- ▶ Synthetic Esters are environmentally friendly
 - Marine
 - Mining
 - Forestry
 - Agriculture
 - Transformers
 - Wind turbines
- ▶ Performance is as good or better than petroleum oils

- ▶ Most esters meet USA EPA Marine (VGP) Vessel General Permit standards



- ▶ Many esters are renewable, sustainable, and have USDA BioPreferred status



- ▶ Wide variety of synthetic esters on LuSC list achieve EU Ecolabel status





Lubricants

PRODUCTS FOR METALWORKING FLUIDS

Esters in metalworking fluids

▶ SIMPLE ESTERS

- Excellent lubricity
- Non-toxic, Non-hazardous handling
- Low color and odor
- Biodegradable

▶ COMPLEX ESTERS

- Boundary lubrication
- Improves AW/EP

▶ ALKOXYLATE ESTERS (PEG/PPG)

- Non-ionic emulsifiers
- Hard water stable
- Boundary lubrication

▶ PHOSPHATE ESTERS

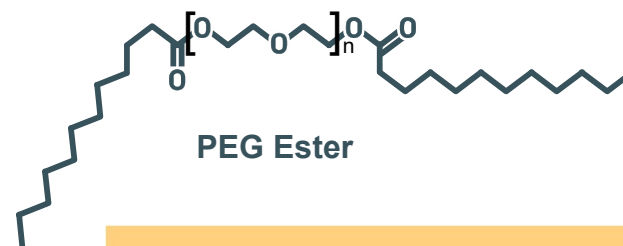
- Emulsifier/Co-emulsifier
- Corrosion inhibitor
- Non-staining



MULSIFAN series

- ▶ Esters of natural fatty acids and polyglycols
- ▶ Emulsifiers with HLB 6 to 14
 - Higher PEG increases HLB
 - Longer fatty acid decreases HLB
 - Diesters have lower HLB
- ▶ Couplers, dispersants, defoamers
- ▶ Good lubricity
- ▶ Non-toxic, Non-hazardous handling
- ▶ Low foam, hard water stable

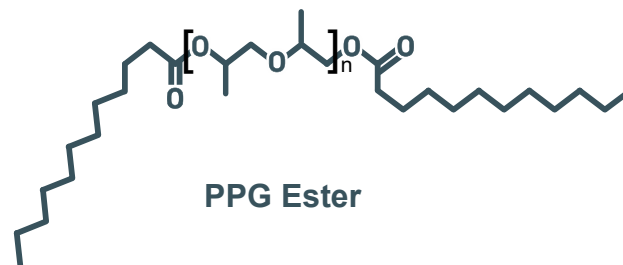
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PEG Ester

▶ FIELDS OF APPLICATION

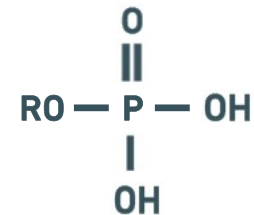
- Metalworking
- Textile lubricants
- Cosmetics
- Oil field
- Water treatment
- Agricultural products



PPG Ester

Phosphate esters (PHOSPHETAL)

- ▶ Monophosphoric acid esters of alcohols and alcohol ethoxylates
- ▶ Available as acid form or neutralized
- ▶ Corrosion inhibitors
- ▶ EP Enhancement
- ▶ Co-Emulsifiers
- ▶ Dispersing agents



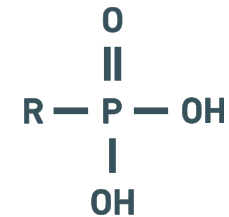
▶ FIELDS OF APPLICATION

- Metalworking
- Lubricants
- Textile finishing
- Oil field
- Water treatment
- Cleaning products



Phosphonates (CUBLEN)

- ▶ Organic carbon directly bonded to phosphorus
- ▶ Wide range of phosphonates available
- ▶ High stability in aqueous systems
- ▶ Outstanding metal chelation
- ▶ Effective at low concentrations
- ▶ Dispersion stabilizers
- ▶ Scale inhibitor



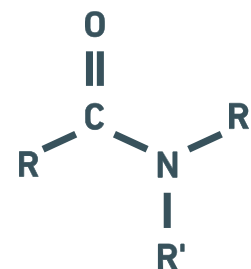
▶ FIELDS OF APPLICATION

- Metalworking
- Lubricants
- Textile finishing
- Oil field
- Water treatment
- Cleaning products



Amides (PURTON)

- ▶ Made from fatty acid + secondary amine
- ▶ Non-ionic emulsifier
- ▶ Corrosion inhibitor
- ▶ Antistatic additive
- ▶ High stability in aqueous systems
- ▶ Effective at low concentrations
- ▶ Dispersion stabilizers



▶ FIELDS OF APPLICATION

- Metalworking
- Oil field
- Lubricants
- Personal Care
- Cleaning and Degreasing
- Metal treatment
- Paints and Coatings



Thank you.

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