Zschimmer & Schwarz

High Performance Lubricant Components with an Eco-friendly profile

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ZSCHIMMER & SCHWARZ

Outline

1. Current market conditions
2. The post-COVID lubricants market?
3. Opportunities for growth
4. Z&S Synthetic Esters & Metalworking Additives
    a. Applications
    b. Chemical Structure
    c. Performance benefits
    d. Environmental advantages
5. Questions?

Lubricants

MARKET CONDITIONS

Global Lubricants Market

- 38 – 40 M MT, global volume demand
  - Zero to 0.5% global market growth 2017-2020
  - Asia +1.5% CAGR
  - Europe + 0.5% CAGR
  - North America -1% CAGR

- 30% average global drop in Lubricants demand Q2-2020
- 30% drop in Steel and Coal production in Q2-2020
- 13% YTD average global decline in Lubricants demand

Synthetic Lubricants Market

- Estimated to be 4-5 % of global demand (excluding Group III)
- Global CAGR Growing (pre-Covid) @ ~3%
  - Asia +4%
  - Europe + 3%
  - North America 2%
- Synthetic lubricants:
  - 40-50% PAO
  - 20-30% Synthetic Ester
  - 15-25% PAG
- Synthetic Esters CAGR +5%

Lubricants Market 2021 – 2022?

- Slow recovery in Automotive, Industrial, Aviation, Marine segments
  - Recent ILMA speaker from IHS indicated that the USA lubricants market will never return to 2019 volume demand levels
  - Recent Fuchs speaker at UEIL indicated that the global market demand will return to 2019 levels, with higher market share in Asia. *and…*
  - Global regulations will create a significant demand for CO2 neutral lubricants in all regions
- Steady market for H1 Food Grade lubricants
- Regulatory and Policy decisions drive growth in Electric Vehicles, Wind Power

Opportunities for Growth

- Marine VGP
- Wind turbine gear lubricants
- Refrigeration, Air conditioning
- Transformers – expanding electrical grid
- Hybrid Lubricants/Coolants for BEV (immersion cooling)
- Increased demand for BioLubricants: for CO2 reduction and Sustainability
- Continued interest in EAL for reduced pollution and bioaccumulation

Lubricants

Z&S PRODUCT LINE REVIEW

Product overview

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

Fields of application for Synthetic Esters

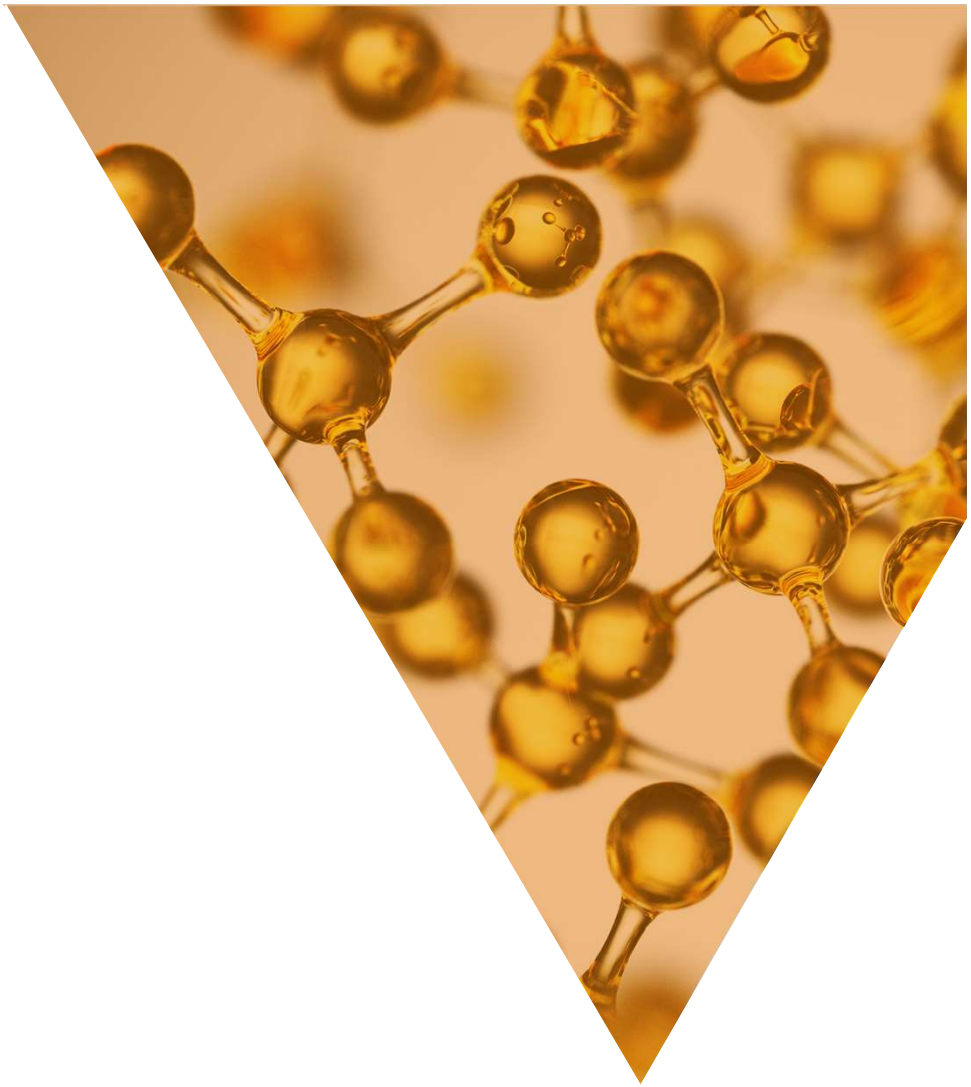
- Hydraulic fluids
- Oven chain oils
- Grease
- Compressor fluids
- Transformer oils
- Metalworking fluids
- Environmentally sensitive applications
- Engine oils
- Transmission fluids
- Gear oils
- Aviation turbine oils
- Drilling mud lubricants
- Food processing H1 lubricants

Performance characteristics

- SYNTHETIC ESTER BASE OILS
  - Boundary lubrication
  - Thermal and oxidative stability
  - Low volatility/high flash point
  - Wide temperature range performance
  - Low sludge or deposit formation
  - Energy efficient
  - Thermal Conductivity
  - Low Heat of Combustion
  - Environmentally and worker friendly

Fields of application for Z&S Surface Active Additives

- Metalworking
- HFA, HFB hydraulic fluids
- Metal cleaning
- Degreasing
- Oilfield drilling mud
- Corrosion inhibitors
- Cooling water treatment
- Textile finishing



Performance characteristics

- ALKOXYLATE ESTERS (PEG/PPG)
  - Non-ionic emulsifiers
  - Hard water stable, Low Foaming
  - Boundary lubrication

- SORBITAN ESTERS
  - Emulsifier/Co-emulsifiers
  - Wetting agents
  - Lubricity additives
  - Bioderived

Performance characteristics

- AMIDES
  - Non-ionic emulsifiers/co-emulsifiers
  - Corrosion inhibitors
  - pH buffer, stabilizer
  - Non-staining

Performance characteristics

- PHOSPHONATES
  - Chelating agents
  - Deposit and scale inhibitors
  - EP/AW additives
  - Fluid stabilizers
- ACID PHOSPHATE ESTERS & ETHOXYLATED ACID PHOSPHATE ESTERS
  - Anionic emulsifiers
  - Corrosion inhibitors
  - EP/AW and friction modifiers

Lubricants

ESTER CHEMISTRY

DESIGN OPTIONS

Lubricant Synthetic Ester types

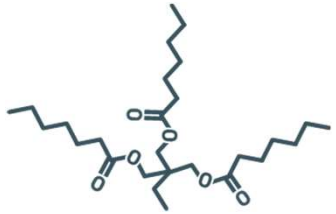
- Mono Esters
- Diesters
- Polyol Esters
- Complex Esters
- Aromatic Esters

Synthetic ester chemistry

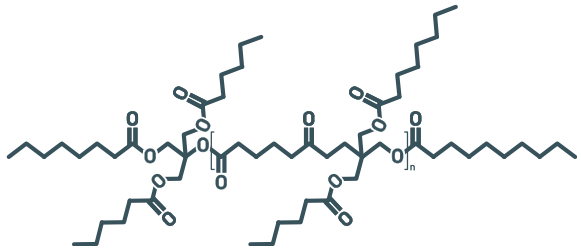
- Monoesters- mono-acids + and mono-alcohols

- Diesters – dibasic acids + mono-alcohols

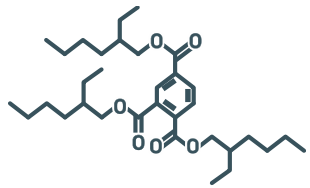
- Polyol esters – neo-polyol + fatty acids



- Complex esters – neo-polyols +di-acids w/ cap



- Aromatic esters – aromatic anhydride + fatty acids



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

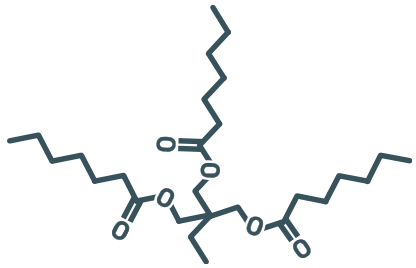
Diesters

- 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

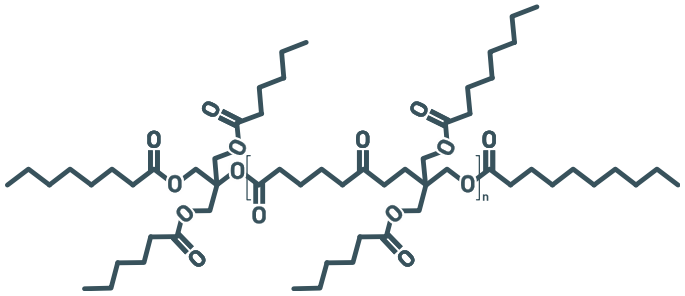
- Made from neo-polyol and mono-acid
- Can be bio-based
- Low to high viscosity
- Low volatility / High flash point
- Low pour point
- Long drain intervals
- Outstanding oxidative stability
- Can be biodegradable



- 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

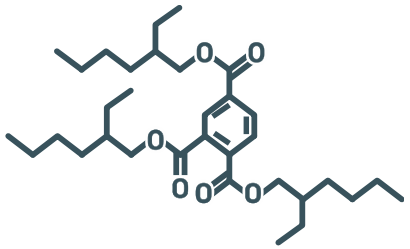
- Capped polymeric ester
- Can be bio-based
- Very high viscosity possible
- Low volatility/High flash point
- High viscosity index
- Antiwear/Extreme pressure
- Can be biodegradable



- 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

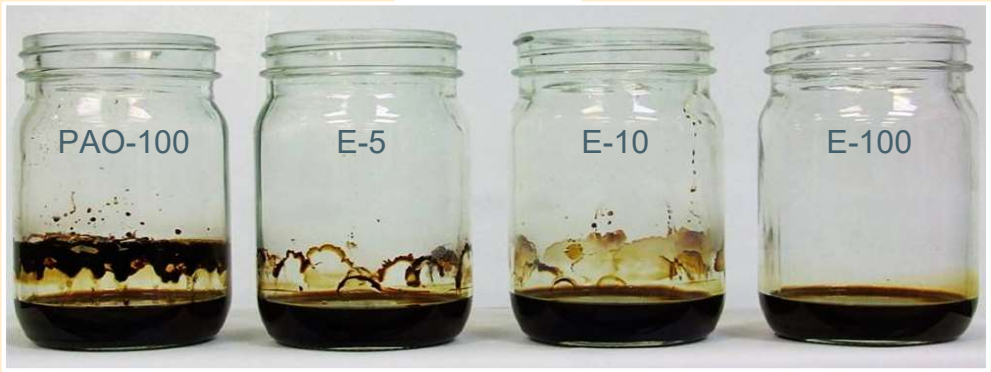
Synthetic Ester Design Considerations

- 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 HX-1 list
  - Environmentally friendly- Components with low aquatic toxicity, EU LuSC list

- Build the ester that delivers 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 260ºC
- RESULTS
  - 6-7% evaporation for all samples
  - 5% POE significantly reduces deposits

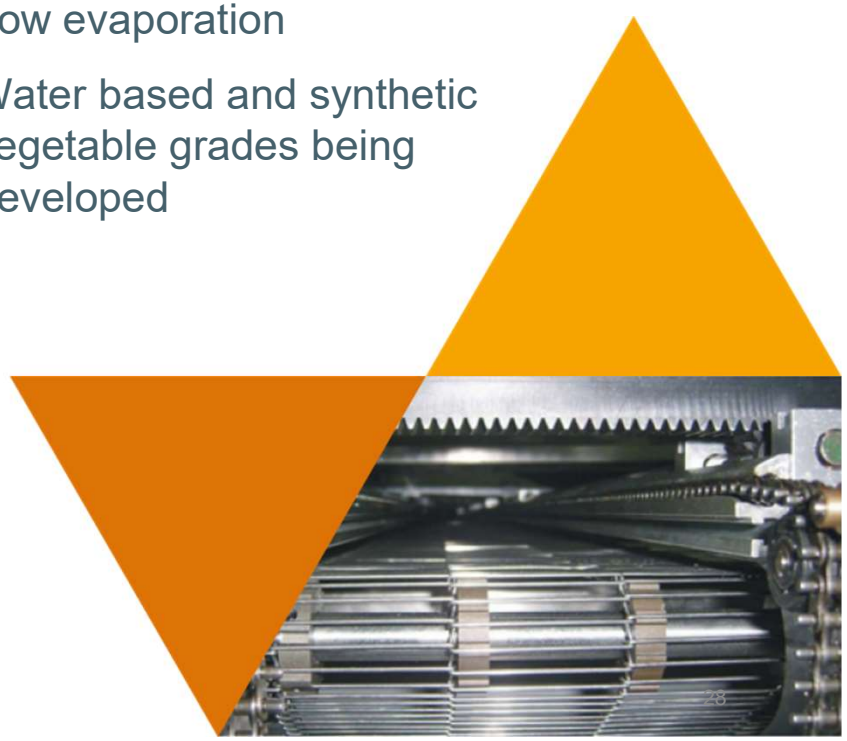


Hydraulic fluids

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

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 275ºC
  - Best oxidative stability, very clean, low varnish
- Aromatic esters – up to 250ºC
  - Higher evaporation, softer deposits
- Complex esters – up to 225ºC
  - 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 240ºC
  - Best oxidative stability, very clean, low varnish
- Arctic grease: down to -60ºC
  - Low viscosity diester or polyol ester
- Bio-based esters: -20 to +175ºC
  - 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
- HX-1 Polyol esters
  - For compressors in food processing plants

Synthetic electrical transformer oils

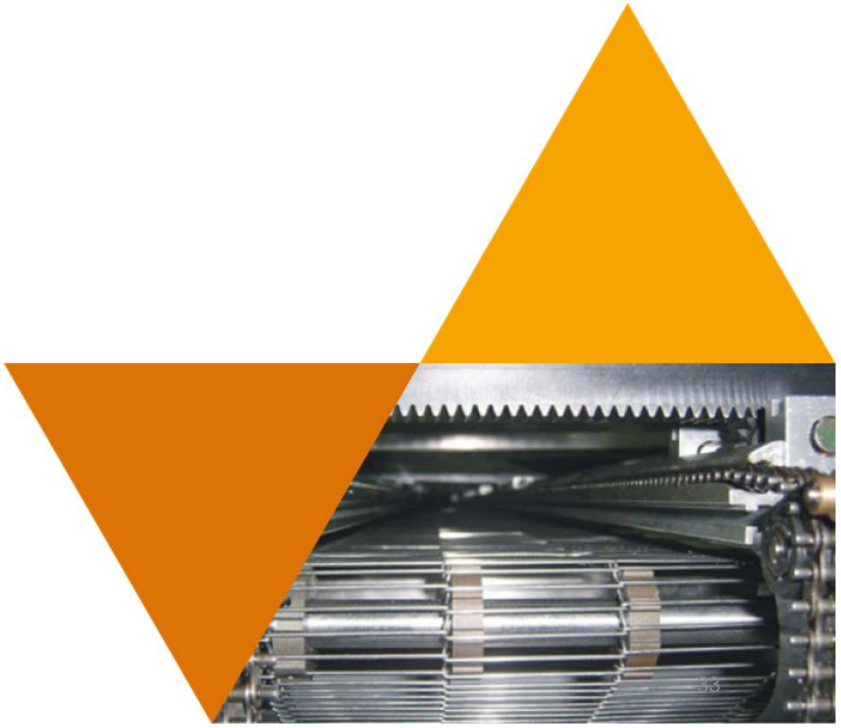
- High flash and fire point
- Good thermal stability for long life
- Low viscosity with low volatility
- Good dielectric properties
- Compliant with IEC 61099
- Environmentally friendly
- Bio-based esters offer improvement over vegetable oils

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

Food Grade H1 Lubricants

- Meeting FDA regulations for potential incidental food contact
  - Hydraulic fluids
  - Pneumatic/Compressor systems
    - Potential for pressurized fluid release or mist
  - Gear and bearing lubricants
    - Accidental drips, leaks
  - Conveyor chains and gears
  - Packaging systems



Environmentally acceptable lubricants (EAL)

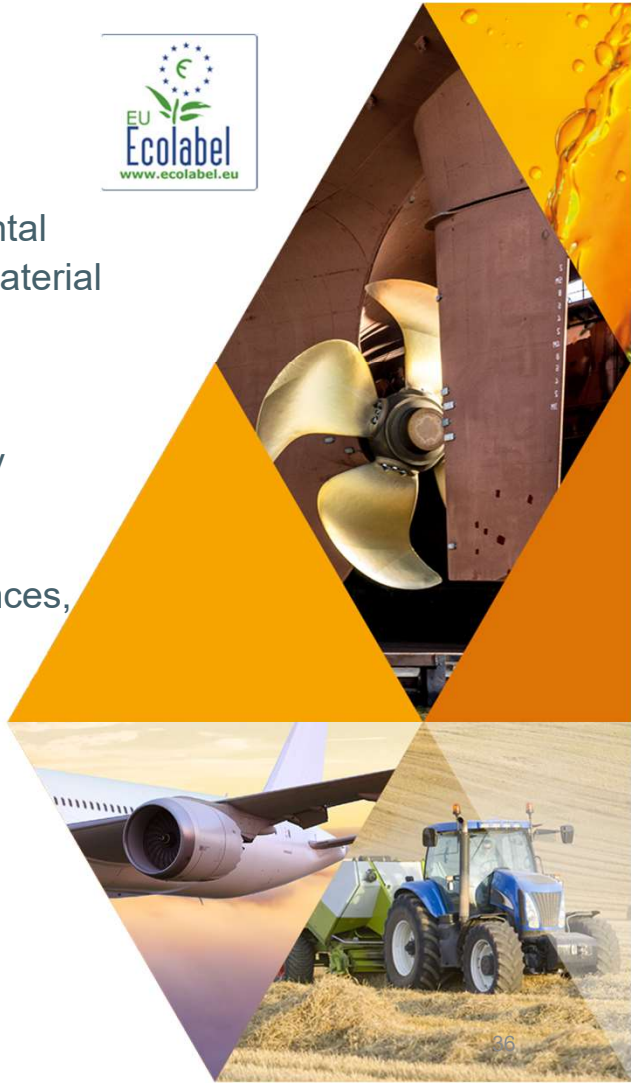
- Most esters meet USA EPA Marine (VGP) Vessel General Permit standards
- Many esters are renewable, sustainable, and have USDA BioPreferred status
- Wide variety of synthetic esters on LuSC list enable EU Ecolabel status
- Mining, Forestry, Wind power, Transformers, Agriculture, Marine

Environmentally acceptable lubricants (EAL)

- Total Loss Lubricants (TLL)
  - chainsaw oils, wire rope lubricants, concrete release agents, total loss greases and other total loss lubricants;
- Partial Loss Lubricants (PLL)
  - gear oils intended for the use in open gears, stern tube oils, two-stroke oils, temporary protection against corrosion and partial loss greases
- Accidental Loss Lubricants (ALL)
  - hydraulic systems, metalworking fluids, closed gear oils intended for the use in closed gears and accidental loss greases

Environmentally acceptable lubricants (EAL)

- The EU Ecolabel identifies products that have reduced environmental impacts throughout their life cycle, from the extraction of the raw material through to production, use and disposal.
- The LuSC-list comprises lubricant substances that meet stringent biodegradation / bioaccumulation, aquatic toxicity, and renewability requirements. (Lubricant Substance Classification list)
- For VGP purposes, products formulated from EU Ecolabel substances, are considered Environmentally Acceptable Lubricants (EALs) which are required by the current Vessel General Permit (VGP).
- ISO 15380 defines performance specifications

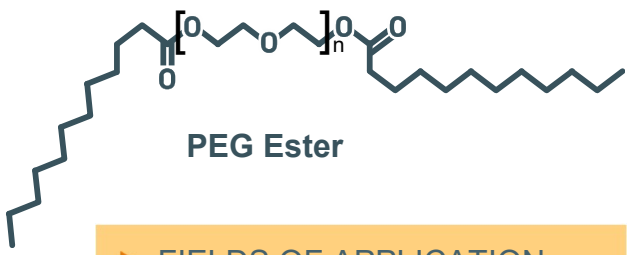


Lubricants

PRODUCTS FOR METALWORKING FLUIDS

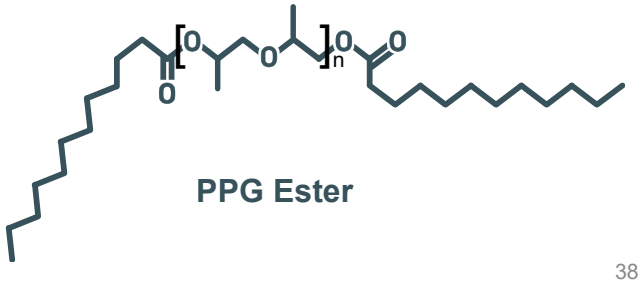
MULSIFAN series

- 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



PEG Ester

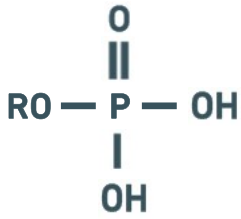
- FIELDS OF APPLICATION
  - Metalworking
  - Textile lubricants
  - Cosmetics
  - Oil field
  - Water treatment
  - Agricultural products



PPG Ester

Phosphate esters (PHOSPHETAL)

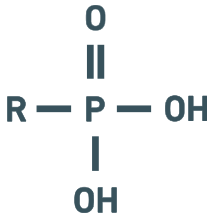
- Monophosphoric acid esters of alcohols and alcohol ethoxylates
- Available as acid form or neutralized
- Corrosion inhibitors
- EP Enhancement
- Co-Emulsifiers
- Dispersing agents



- FIELDS OF APPLICATION
  - Metalworking
  - Lubricants
  - Textile finishing
  - Oil field
  - Water treatment
  - Cleaning products

Phosphonates (CUBLEN)

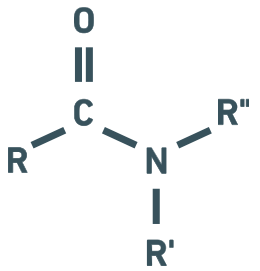
- Organic carbon directly bonded to phosphorus
- Wide range of phosphonates available
- High stability in aqueous systems
- Outstanding metal chelation
- Effective at low concentrations
- Dispersion stabilizers
- Scale inhibitor



- 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

Lubricants

MANUFACTURING SITES

Lubricants division manufacturing

- ZS manufacturing Synthetic Esters in Milledgeville, GA since 2005
- ZS manufacturing Synthetic Esters in Tricerro, Italy since 2016
- 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 alkoxylate 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

Z&S Italiana

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

Lubricants

CONCLUSION

Opportunities for Growth

- How is your product line positioned to capture growth?
- What is your approach to the CO2 neutral future?
- Can you offer “natural” energy efficiency?
- Z&S has the broadest line of commercially available Synthetic Esters; or, tailor-made products to fit your unique formulation
- Z&S offers standard or tailor-made Metalworking Additives to fit your needs
- Z&S is ready to support your product line growth

Thank you !

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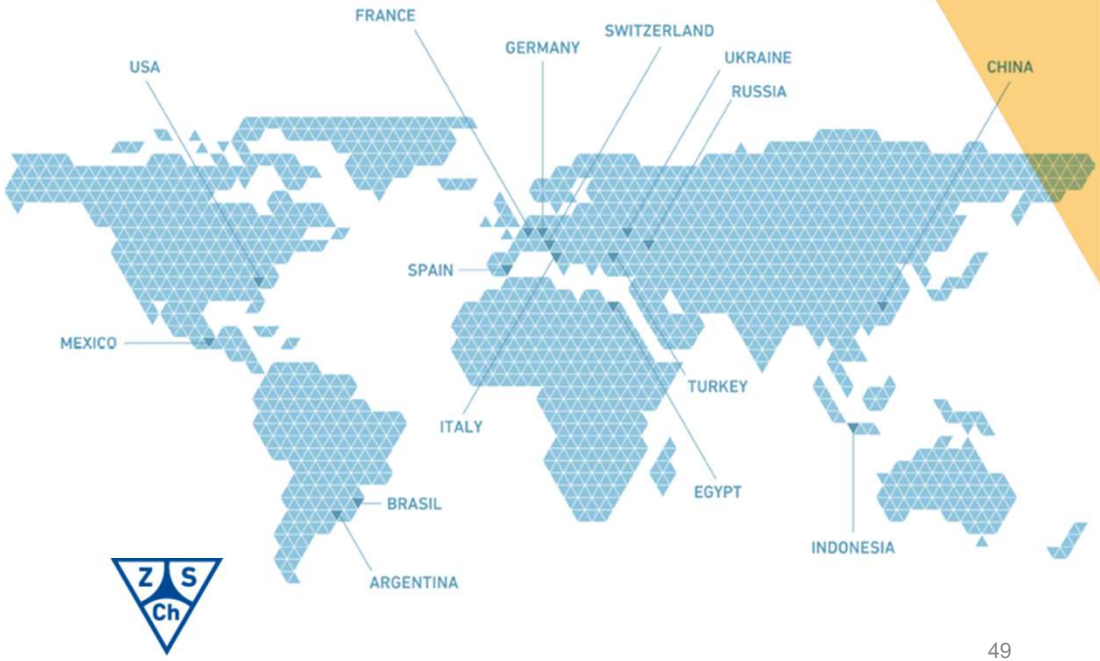
ZSCHIMMER & SCHWARZ

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 2019



Business divisions

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