Understanding features and benefits associated with using a secondary ester in a lubricant formulation

Vincenzo Aruta

IMCD Lubricants & Energy

Creating a world of opportunity

How can we design a lubricant that is compatible with environmental sustainability?

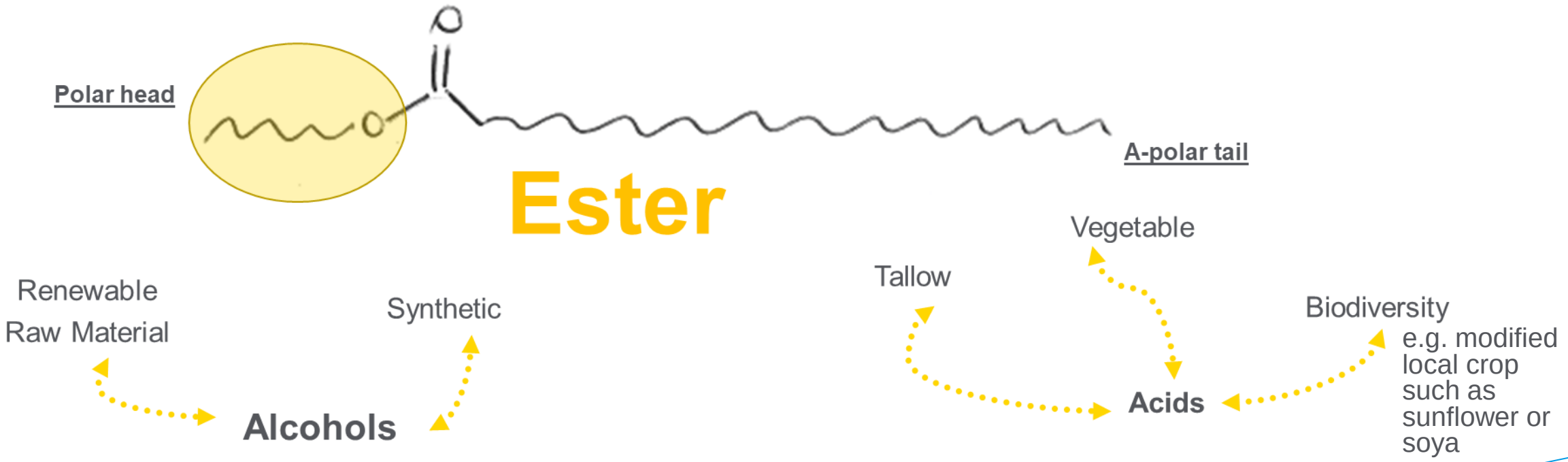
Bio-Base Stocks in Lubricant Applications

Main Advantages of using Esters

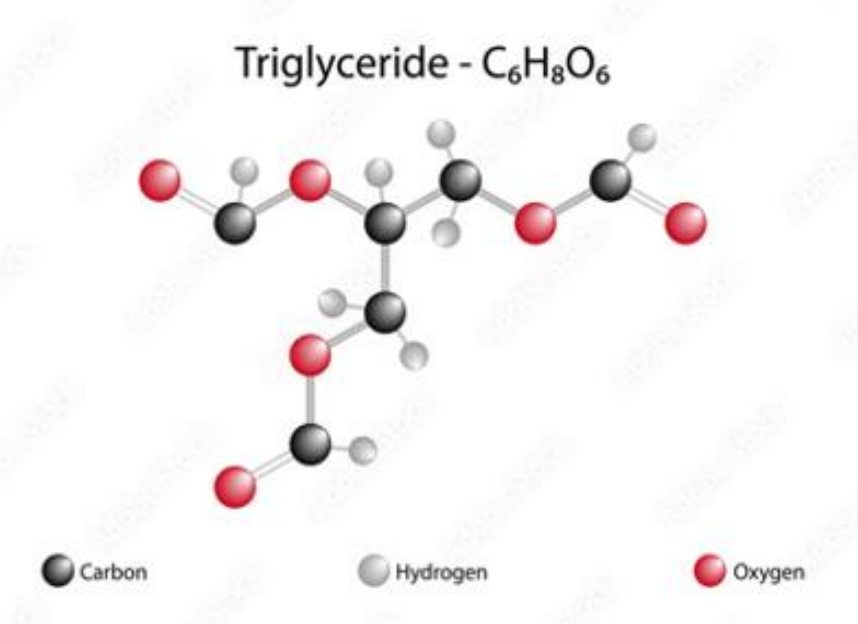
- **High sanitation tolerability**
  Does not irritate the skin and respiratory system
- **Greater cooling capacity**
  The specific heat of the ester is greater than mineral oil
- **High flash point**
  Allows for unattended mechanical processing
- **High fire point**
  It does not maintain a flame.
- **High smoke point**
  Esters allow for increasing productivity without generating mists or emissions
- **High intrinsic viscosity index**
  Stability in lubricants as a function of the temperature
- **Not explosive at atmospheric pressure in any proportion with air**
  Vegetable ester allows for unattended mechanical processing

Defining an Ester:
Combining properties of Sustainability & Functionality

Ester bases are more lubricating than mineral bases as their chemical structure makes them polar and thus absorbed on the metallic surface



Natural Fats & Oils are called Tri-glycerides meaning “Tri-Esters of Glycerol”



This oil can be used as the base fluid for lubricating oils or it can be treated and split into components (which are then used to form synthetic esters).

How can we improve the performance ?

Mono-Esters: monoacid + ALCOHOL

- Good lubricating properties
- Low viscosity

Di-Ester: diacid + ALCOHOL

- Low viscosity and low pour point
- Good thermo-oxidative stability

Aromatic Esters: phthalic or trimellitic Anhydride + ALCOHOL

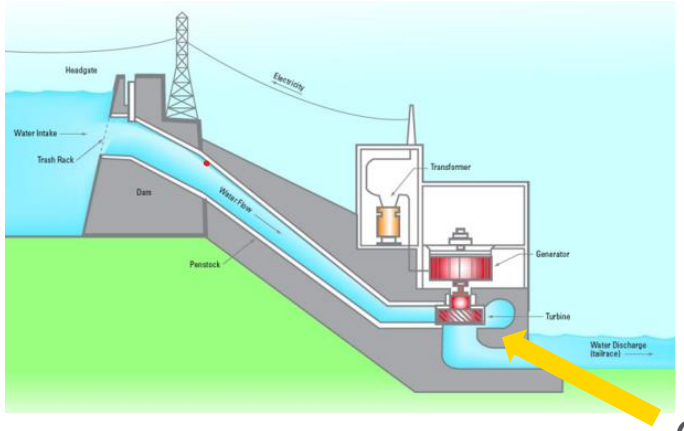
- Applications at high temperatures
- High thermo-oxidative stability
- Low biodegradability

Polyol Esters: monoacids + POLYOLS

- Excellent lubricating properties

Lubricant Application – Case Study

A turbine located in a hydroelectric power plant was lubricated by mineral oil



Ogive

The turbine is moved from the water captured from a nearby river.
The bottom part of turbine (ogive) is in contact with water.

Leakages from turbine was release directly with into the river.

Customer topics:

- ✓ Assess the problems caused by the use of a mineral oil used in a turbine
- ✓ Suggest a possible sustainable solution

Customer requests

- ✓ Replace mineral oil with sustainable solution, to minimize the environmental impact
- ✓ Minimize the leakages
- ✓ Improve the filterability, to avoid the pump

Lubricant Application – Case Study

Step 1: We analysed the customer's sample in our laboratory to verify the chemical and physical characteristics of the product in use

Mineral Oil in use			
TEST	**UNIT**	**RESULT**	**METHOD**
Appearance	-	Clear	Visivo - Visual
Colour	-	Light Amber	Visivo - Visual
Specific gravity @ 20°C	[g/cm3]	0,875	ASTM-D-1298
Viscosity @ 40°C	[mm2/s]	65,32	ASTM-D-445
Viscosity @ 100°C	[mm2/s]	11,82	ASTM-D-445
Viscosity Index	-	179	ASTM-D-2270
Pour point	[°C]	-30	ASTM-D-97
I.R. Spectrum	-	mineral based	A-001/99
Filterability DENISON HF0	s	388	Denison
Filterability DENISON HF2	s	813	Denison
Biodegradability	-	n.a.	OECD 301 B

Viscosity @ 10°C	**[mm2/s]**	**270,2**	**calculated**

Step 2: Key requirement; identify the parameters to address the issues highlighted by the customer

Step 3-4: Following the analysis, we determined the factors needed to deliver a positive outcome:

Biodegradability: Addresses the problems of leakages in water

Filterability: to improve the circulation of the oil within the system and avoid the pump use

Viscosity Index: to minimise the leakages, as they directly relate to the water temperature.*

*The temperature of the ogive is driven by the water temperature. We needed to guarantee an increase of viscosity in line with decreasing water temperature.

Lubricant Application – Case Study

		IMCD	Mineral Oil	
TEST	UNIT	RESULT	RESULT	METHOD
Appearance	-	Clear	Clear	Visivo - Visual
Colour	-	Pale Yellow	Light Amber	Visivo - Visual
Specific gravity @ 20°C	[g/cm3]	0,91	0,875	ASTM-D-1298
Viscosity @ 40°C	[mm2/s]	68,83	65,32	ASTM-D-445
Viscosity @ 100°C	[mm2/s]	10,82	11,82	ASTM-D-445
Viscosity Index	-	147	179	ASTM-D-2270
Pour point	[°C]	-36	-30	ASTM-D-97
I.R. Spectrum	-	synthetic based	mineral based	A-001/99
Filterability DENISON HF0	s	280	388	Denison
Filterability DENISON HF2	s	350	813	Denison
Biodegradability	-	69,1%	n.a.	OECD 301 B

Viscosity @ 10°C	[mm2/s]	337,1	270,2	calculated

Proposal & Results

Sustainability: We proposed an ester with high biodegradability; this improved the environmental profile of the solution.

More efficient lubrification, this means an average increase in the hydrodynamic circuit temperature of 10%, leading to:

- **Lower wear conditions**
- **Longer lifetime of the spare parts of the circuit**

Leakages: reduced by 40% from initial value

Filterability: this target was largely met, such that the pump could be eliminated. As a direct consequence, the project delivered:

- **Significant savings from an energy standpoint**
- **Reduction in system complexity**

Bio-Base Stocks in Lubricant Application

Limitations of primary esters

- **Hydrolytic Stability**
- **Solvency**
- **Thermo-Oxidative Stability**

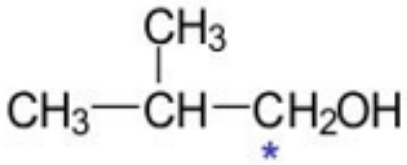
How can we improve the performance ?

How can we change the performance of an ester?

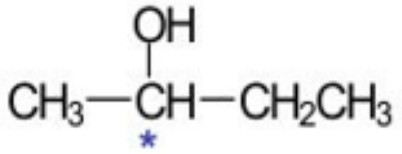
- Increase or Decrease Viscosity
- Improve Cold Temperature Properties
- Increase or Decrease Polarity
- Improve Oxidative Stability
- Improve Hydrolytic Stability

How can we change the performance of an ester?
Switching from primary to secondary alcohol as the starting material

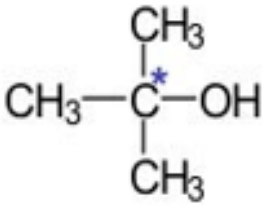
Examples of Classifications



Primary alcohol



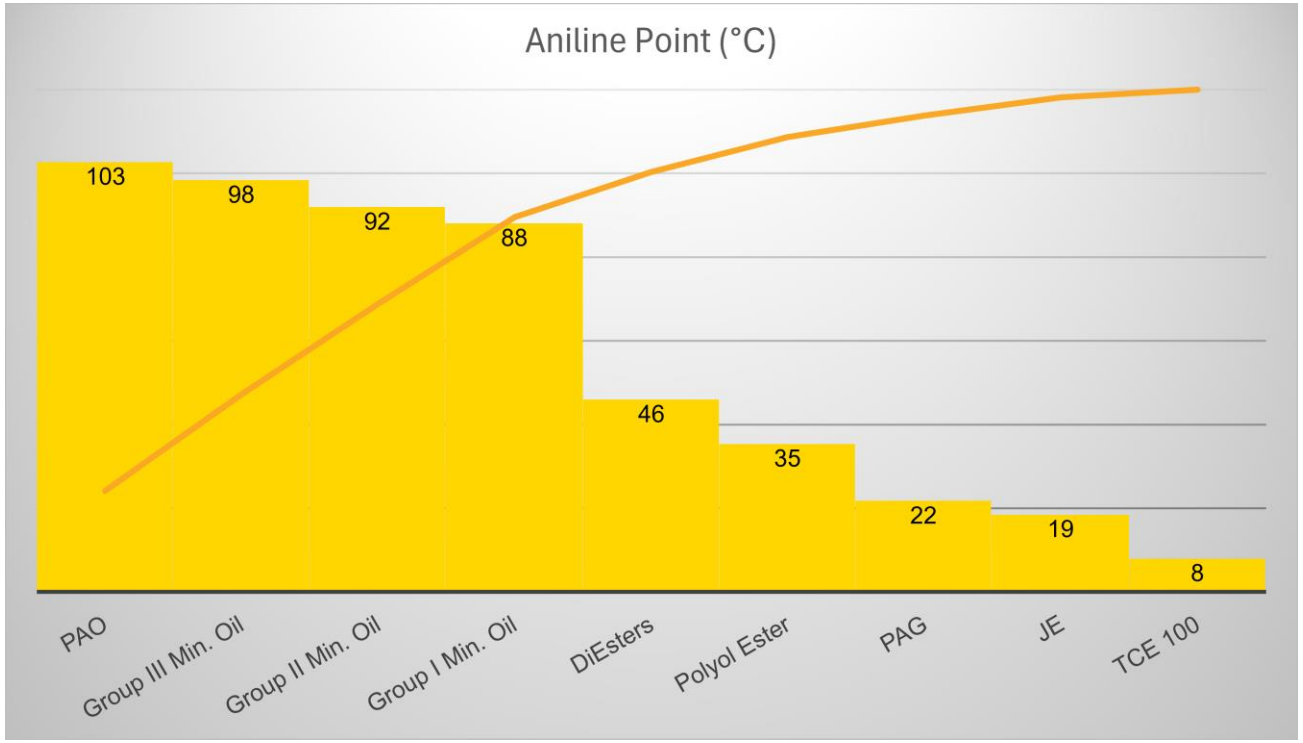
Secondary alcohol



Tertiary alcohol

IMCD Innovative Esters Solvency – Aniline Point

Base Oil	KV 40°C (cSt)	Aniline Point (°C)
IMCD JE	15.0	18,5
IMCD TCE 100	100	8
Group I	50	88.1
Group II	44.0	92.0
Group III	37.0	98.4
PAO	38.0	102.7
PAG	28.0	21.8
DiEsters	28.0	46.0
Polyol Ester	53.0	35.4



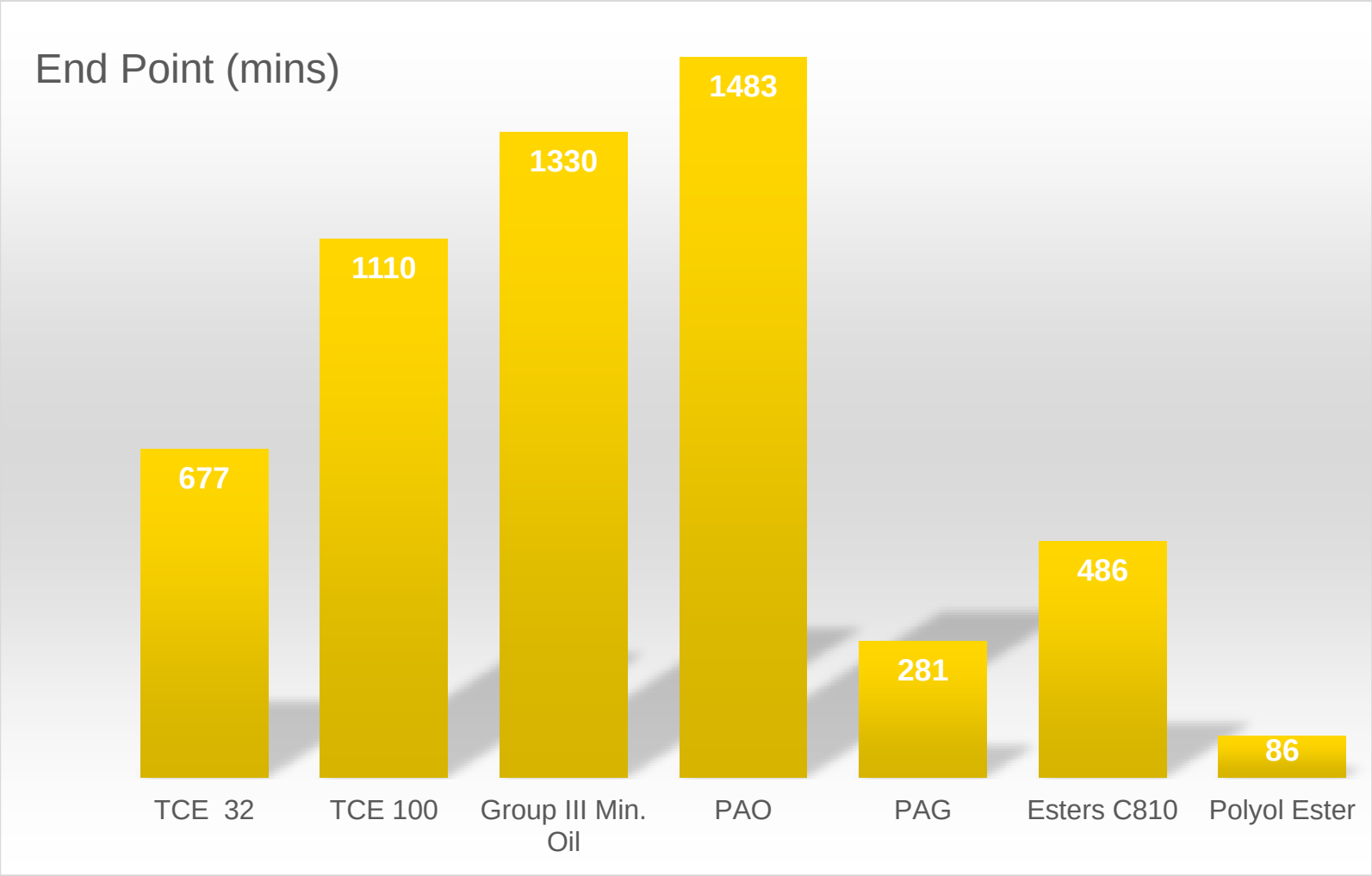
IMCD Innovative Esters - Hydrolytic Stability

Test Method: ASTM D2619
Conditions: 93ºC,
144 hours (modified from 48 hours)

	PAO Base oil	Paraffinic Base oil	Naphthenic Base oil	IMCD TCE 100
Weight Change of Copper Panel, (mg/cm2)	-0.092	0.00	-0.033	**-0,053**
Appearance of Copper	Shiny, 2c	Shiny, 1b-2c	Shiny, 1b	**Shiny, 2c**
% Change in Viscosity	-0.41	+0.04	+11.3	**-0,41**
Change in Acid Number, mg KOH/g	+0.05	+0.01	+0.17	**+0.17**
Total Acidity of Water Layer, mg KOH/g	3.11	0.11	0.06	**0,19**

Important behaviour: increasing viscosity of secondary esters denotes improved hydrolytic stability

IMCD Innovative Esters – Oxidative Stability RPVOT ASTM D2272



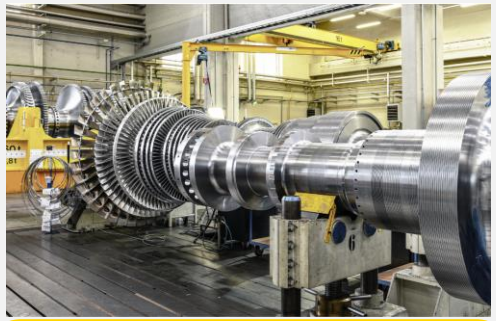
Applications for secondary esters

Hydraulic Oils

Metalworking Fluids

Gear Oils

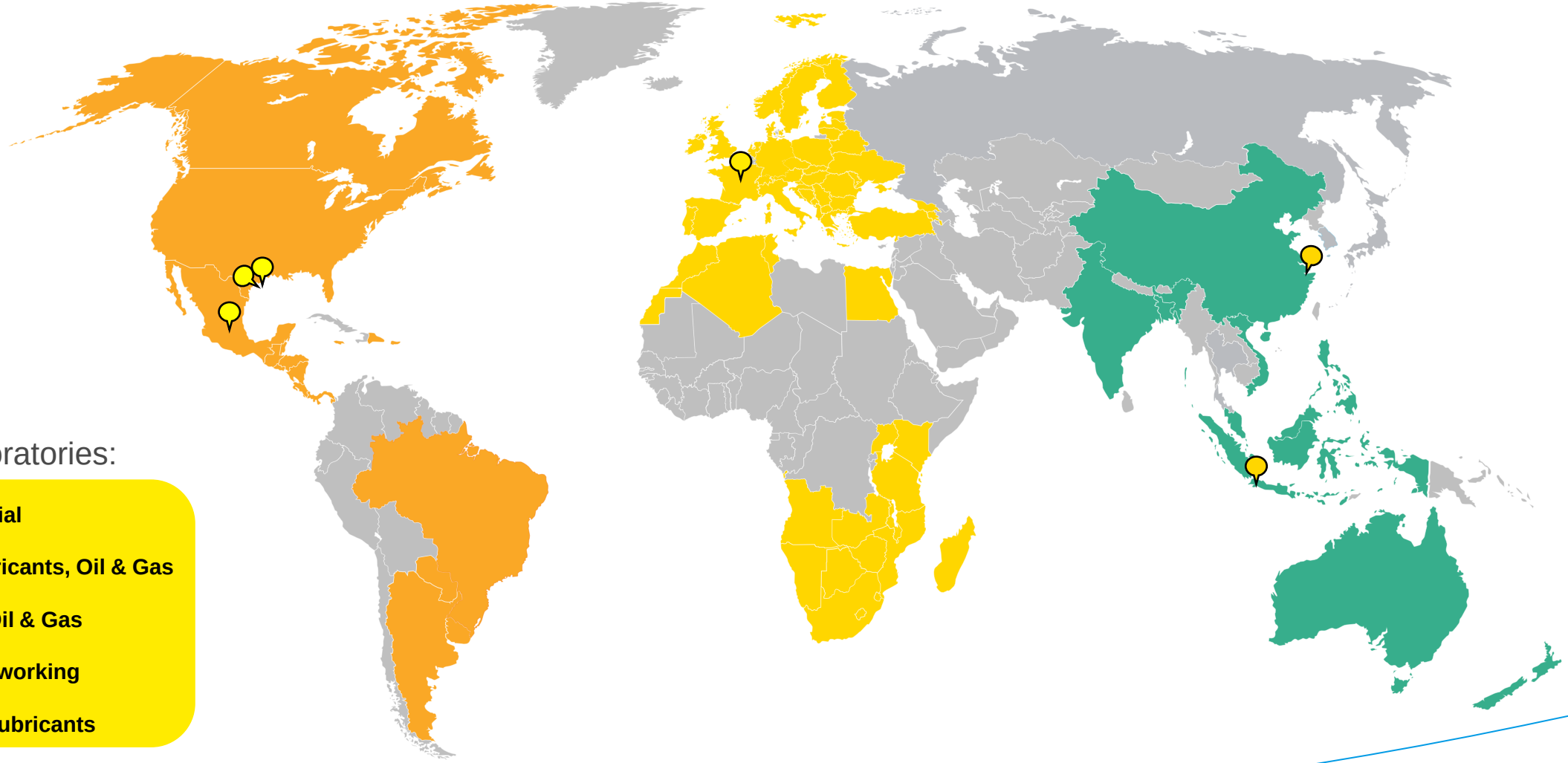
Air Compressor Oils



Turbine Oils

Greases

IMCD Lubricants & Energy | Technical Centres



Active laboratories:

Paris: Industrial

Houston: Lubricants, Oil & Gas

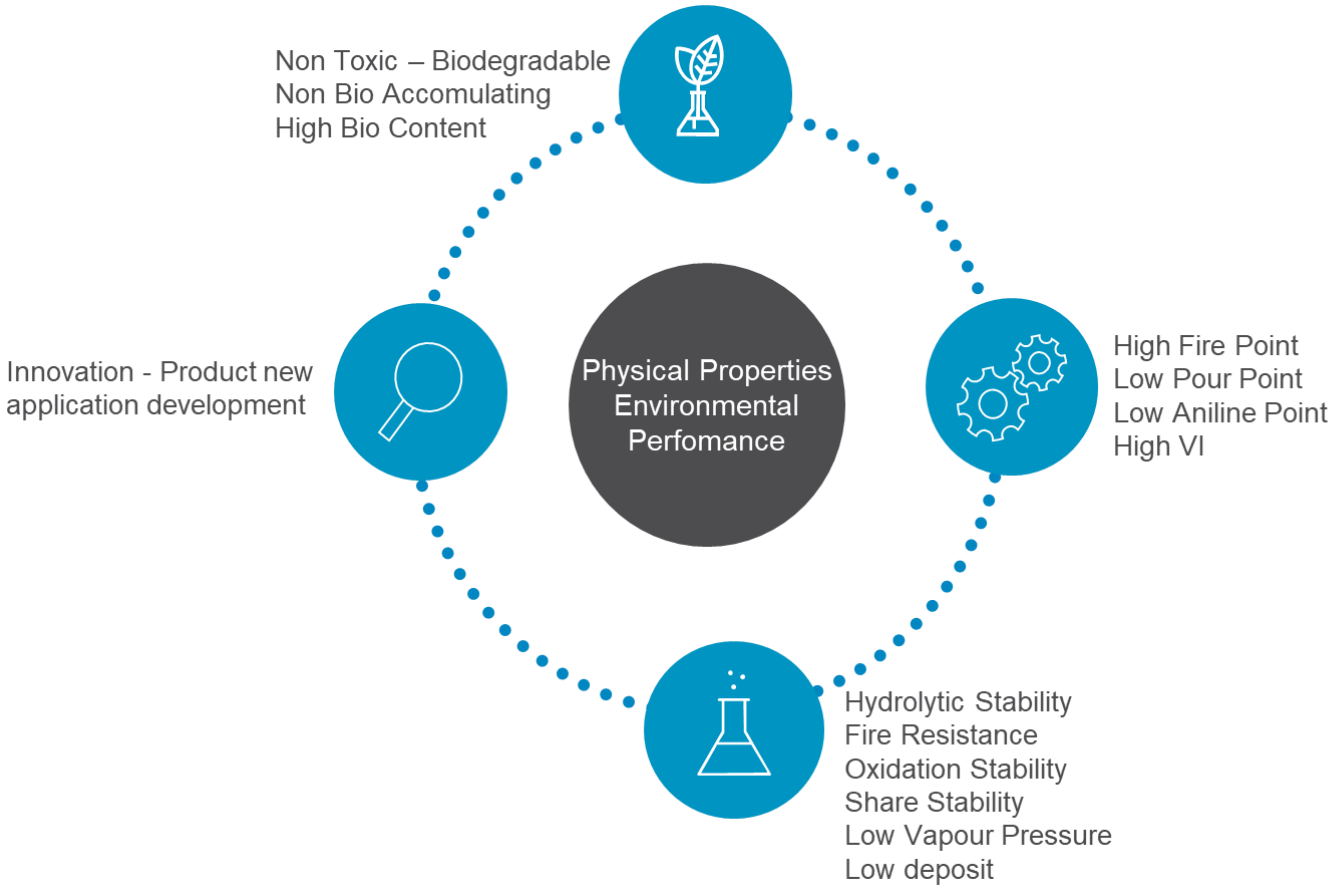
Mexico City: Oil & Gas

Jakarta: Metalworking

Guangzhou: Lubricants

Bio-Base Stocks in Lubricant Application – Conclusion

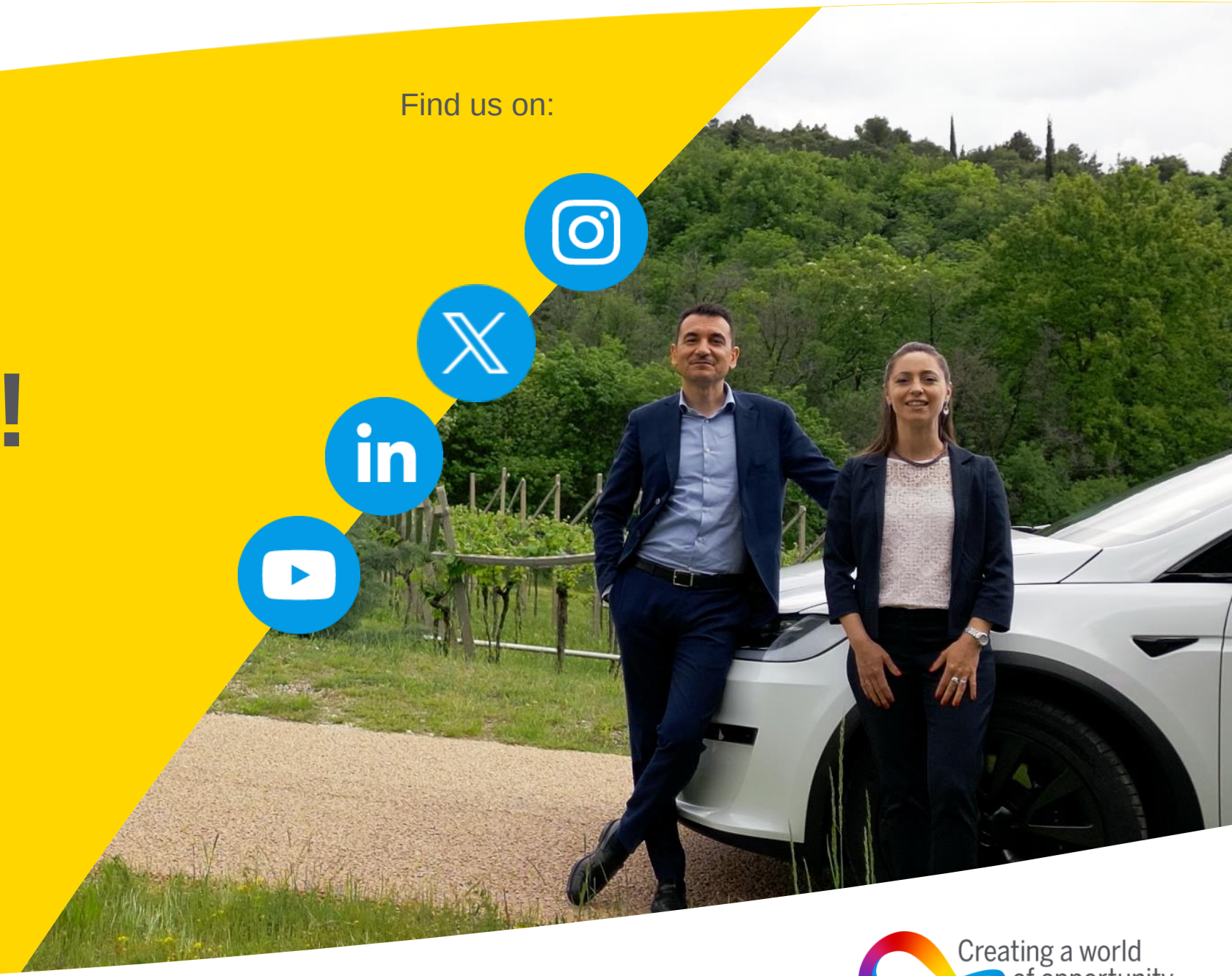
- Hydrolytic Stability
- Solvency
- Thermo-Oxidative Stability
- Sustainable Products
- **Lower price level**



IMCD

Thank you!

Find us on:



Creating a world of opportunity