

IENICA

BIOLUBRICANTS

~ Market Data Sheet ~

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Introduction

This market information booklet is one of several that have been written as part of the current IENICA workstream of the IENICA-INFORRM project.

These booklets are the first to try to characterise the specifications that a farm feedstock must achieve to be acceptable in the non-food products sector. The lack of specifications has been highlighted as a bottleneck in development of such products. Whilst it has been quite difficult to produce these booklets and there is no doubt they will be superseded in time, they will certainly form the first step in assisting growers match market requirements with their agricultural feedstocks.

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The primary functions of lubricants are decreased friction and wear, and other effects including heat transfer; contaminant suspension; liquid sealing and corrosion protection.

Between 5,000-10,000 different lubricant formulations are necessary to satisfy more than 90% of all lubricant applications.

European lubricant consumption, 2004:

47%: automotive industry
32%: industrial lubricants (including hydraulic oils which account for approximately 15% of total lubricant consumption)
11.3%: process oils
9.4%: marine and aviation

Industry claims suggests that over 90% of all lubricants could be replaced by biolubricants: this gives a potential European market of up to 9 million tonnes of biolubricants per year.

To meet these requirements most modern lubricants are complex formulated products consisting of 70-90% base oils mixed with functional additives to modify the natural properties (i.e. cold stability, oxidation stability, hydrolytic stability, viscosity and viscosity index, corrosion) and fulfil the requirements for the fluid. The base oil can be mineral, vegetable, synthetic or re-refined:

- **Mineral oils** are the most commonly used today. They consist predominantly of hydrocarbons but also contain some sulphur and nitrogen compounds with traces of a number of metals.
- **Vegetable oils** used in lubricants are mainly derived from rapeseed, sunflower, palm and coconut.
- **Synthetic oils** include among others polyalphaolefins (PAO), synthetic esters and polyalkylene glycols (PAGs). PAOs are petrochemical derived synthetic oils that most resemble mineral oils. Synthetic esters form a large group of products, which can be either from petrochemical or oleochemical origin. Five different categories of synthetic esters can be distinguished: monoesters, di-esters, phthalate esters, polyol esters and complex esters. Polyalkylene glycols (PAGs) are polymers from petrochemical origin commonly made from ethylene oxide and propylene oxides
- **Re-refined oil** is used oil that undergoes an extensive re-refining process to remove contaminants to produce fresh base oil. The base oil is then sold to blenders who add additive packages to produce lubricants.

There is an increasing demand for environmentally-compatible lubricants, particularly in areas where they can come into contact with water, food or people. There is no universal definition used to determine environmental friendliness, however.

'Biolubricants' are often, but not necessarily, based on vegetable oils. In all different current discussions biolubricants are at the least products for which formulation for (a certain extend of) rapid biodegradability and low environmental toxicity is a deliberate and primary intention. However, no universal agreement exists on the origin and chemical composition of the biolubricants. They can also be synthetic esters which may be partly derived from renewable resources i.e. the hydrolysis of fats and oils to produce the constituent fatty acids. They can be made from a wider variety of natural sources including solid fats and low grade or waste materials such as tallows. Genetically-modified vegetable oils, such as high-oleic sunflower and rapeseed, are also beginning to find use in applications where higher oxidative stability is needed. Vegetable oils offer biodegradability and low toxicity. Obviously during the formulation of a biodegradable and low toxicity fluid the additives must be biodegradable and have low toxicity.

In the beginning of the development of biolubricants (some 20 years ago) the focus was on the formulation of products based on pure vegetable oils. Over the last ten years, however, the trend has been the use of synthetic ester types which may be partly derived from renewable resources. To avoid controversies associated with the term biolubricants, as well as to create a starting point for more environmental preferable products to enter the market, a European harmonization of the term is highly desirable.

CTVO-Net: The elements to be considered when developing an environmentally friendly lubricant:

- Chemical environment (cost and performance)
- Technological environment (compatibility with the working fluids in the process)
- Working environment (health and safety conditions)
- Natural environment (recycling of the exhausted fluids and disposal of the waste fluid)

The two most significant opportunities for biolubricants are:

- **High-risk lubricants** i.e. in applications where there is a high probability of accidental exposure of the lubricants to sensitive environments e.g. hydraulic equipment in forests and by water
- **Total-loss lubricants** – where, by the design of the equipment or application the lubricant ends up almost entirely in the environment.

The market for natural esters is increasing, but nevertheless strong efforts are still needed from ester base oil, additive and lubricant industry to develop improved products which will be generally more accepted by toxicologists and legislation as well as by end users.

There is a necessity to develop more analytical tailor-made methods to better understand the nature of lubricants and to better study which are the modifications occurring during their use. Simply transferring the well-known methodologies from mineral oils to vegetable oils would result in an unrealistic picture of these products. A preliminary chemical evaluation of base esters should detect defects that may cause problems during in-use operation.

Effects of Qualitative Parameters on Performances

Parameter	Affects
Acidity	corrosion properties cold stability hydrolytic stability fire resistance poor Noack behaviour
Partial esters (high OH val)	cold stability thermal stability corrosion properties emulsivity hydrolytic stability
Free monoalcohol	flash point
Free polyalcohol	formation of unsolubles
Free methylesters	low viscosity fire resistance poor Noack score
Catalyst residue	soaps formation unsolubles hydrolytic stability thermal stability oxidation stability

Source: Sala, M (2000) Paper presented at the 2nd workshop on lubricants and hydraulic fluids, CTVO-Net, Milan 10-11 Feb 2000

A strong effort must be made to set up and standardise methods for quality control.

Benefits of Biodegradable Lubricants

- Less emissions because of higher boiling temperatures ranges of esters (Native triglycerides lead to partly gummy structures at high temperatures and can build eye irritant acroleins)
- Total free of aromatics, over, 90 % biodegradable oils, non water polluting,
- Oil mist and oil vapor reduction, leading to less inhalation of oil mist into the lung.
- Better skin compatibility, less dermatological problems.
- High cleanliness at the working place
- At least equal and often higher tool life, because:
- Higher wetting tendency of polar esters lead to friction reduction.
- Higher Viscosity index: their viscosity does not vary with temperature as much as mineral oil. This can be an advantage when designing lubricants for use over a wide temperature range. This can also result in lower viscosity classes for the same applications combined with easier heat transfer.
- Higher safety on a shop floor, because of higher flashpoints at the same viscosities
- Cost savings on account of less maintenance, man power, storage and disposal costs.

Disadvantages of Biodegradable Lubricants

- Low temperature limitations. The addition of co-solvents such as synthetic fluids or mineral oils can improve the low-temperature properties of vegetable oils
- Partly worse smell and compatibility with paintings and sealings
- More flushing tendency because of lower viscosity
- Less oxidation and hydrolytic stability's of vegetable oils
- Filter clogging tendency depending on ester type and formulation
- Depending on the ester type worse air release or foaming and corrosion protection behaviour
- Depending on ester type yellow metal discoloration can occur

Impurities in vegetable oils can result from:

- Natural minor ingredients (typical to a given oil)
- Degradation products (seed and oil storage)
- Remaining chemicals (growing and processing), their degraded products
- Contaminants from the equipment/high temperature/other oils

New Sources of Vegetable Oils

Industry suggests that, when developing new oil crop species, targets should be:

- Improved seed yield
- Improved oil yield
- Improved concentration of the main fatty acid
- Increased disease resistance

However, some industry opinion is that bringing new vegetable oils onto the market is not necessary, and the current vegetable oils on the market cover requirements.

Industry needs a stability of price and supply of these oils as well as a robust long term European Union policy on industrial crops, allowing them to plan and set up investments. A further strong requirement is the necessity for rules and standardisation for the classification of different raw materials.

Cost

The high price of biolubricants (both on the basis of vegetable oils and especially based on synthetic esters) is the main restriction for the development of biolubricants at the current time. They are generally between 1.5 and 5 times more expensive than conventional lubricants. Economical and environmental balance needs to be performed in order to minimise the higher price i.e. economic cost versus true cost.

In several European countries regulations and policies exist in favour of biolubricants.

- In several German *Länder*, in Austria and Switzerland regulations are in place which forbid the use of mineral oil based lubricants around inland waterways and in forest areas. In addition, the German federal government has introduced the programme called “Market Introduction Programme (MIP) Biolubricants and Biofuels” for reimbursement of costs associated with substituting mineral oil based lubricants by lubricants based on a renewable mass content higher than 50%. This programme, which is managed by the FNR (German Agency of Renewable Resources), is a success especially for hydraulic fluids.
- The Swedish City of Gothenburg has set up an advice and technology programme for lubricant products which has encouraged the manufacturing industry to switch to biolubricants. This so-called "Ren Smörja" (Clean Lubricants) project was a co-operation between municipal authorities, consultants and industries and has resulted in 1998 in environmental criteria for lubricating greases and hydraulic fluids. These criteria have been identified and are now a part of the Swedish Standard. In addition, in the Scandinavian countries a tax exemption on biolubricants is in place.
- In Italy there is a tax in place on mineral oils and hence products like lubricants containing them.
- Portugal introduced in 1991 a regulation mandating the use of biolubricant two-stroke engine oils in outboard boat engines.
- Belgium has legislation in place, which requires biolubricants to be used in all operations taking place near non-navigable waters.
- In the Netherlands, the Dutch Ministry of Spatial Planning, Housing and the Environment issued a policy and action programme in favour of biolubricants in 1996. Tax incentives affecting biolubricants are operating under the Dutch VAMIL, which allows for accelerated depreciation of environmental investments.
- Within the USA, the Department of Agriculture is proposing to establish guidelines for designating items made from biobased products (including plant based lubricants) that would be afforded Federal procurement preference, as required under the Farm Security and Rural Investment Act of 2002.

Again, one should realise that the definitions for biolubricants used in the different regulations and policies motioned above are not consistent.

National and European policy and regulations will be major drivers of the further development of the biolubricants market. Several national ‘eco-labels’/schemes and one international standard have been developed in recent years throughout Europe, setting requirements for the ecological and technical characteristics of lubricants:

Nordic Countries (Nordic Swan): Lubricating oils: separate requirements are imposed to chain oil, mould oil, hydraulic oil, 2-stroke oil, lubricating grease, metal cutting fluid and transmission-/gear oil. The criteria of the Nordic Swan for lubricants can be obtained from: www.svanen.nu/Eng/default.asp. There are currently no products carrying the Nordic Swan. An important feature of the scheme is a relatively high requirements for renewability, although some consider this is the reason for no products currently carrying the Nordic Swan (this could also be due to the high costs related to the procedure of gaining the eco-label).

Sweden: Standard for hydraulic fluids (SS 155434) and greases (SS 55470). There are currently 61 products qualifying for the SS 155434 (hydraulic fluids) and about 20 products qualifying for SS 155470 (greases). The success of the Swedish Standard is often ascribed to the fact that the criteria were developed in close co-operation between manufacturers and end-users. A summary of the criteria and a list of products that comply with SS 155434 and SS 155470 can be obtained from http://www.sp.se/km/en/tech_ser/kmo/hydraul.htm (hydraulic fluids) and http://www.sp.se/km/en/tech_ser/kmo/grease.htm (greases).

Germany (Blue Angel): Criteria have been developed for the following lubricant subgroups: RAL UZ-79 Hydraulic fluids; RAL UZ-48 Rapidly Biodegradable Chain Lubricants for Motor Saws; RALUZ-64 Lubricating oils and greases (also applicable to concrete release agents). There are 235 different products qualified within these and the Blue Angel is considered to be a transparent, credible programme. Public procurement gave a strong impetus to the increasing success of the Blue Angel in the case of lubricants. The criteria and lists of products that comply with the Blue Angel RAL UZ-79, RAL UZ-48 and RALUZ-64 can be obtained from <http://www.blauer-engel.de/Englisch/index.htm> .

France (NF-Environment Mark): Developed an eco-label for chain saw oils in 2003. There are no products carrying the NF-Environment mark at present because it is a very recent scheme.

Austria: Established an eco-label for chain saw oils (UZ 14 Chain Saw oils) in 1991. Until three years ago there were four licence holders but there is at present only one remaining. This is mainly due to concentration processes of international companies and to change in company strategies.

The Netherlands (VAMIL regulation): Environmental criteria have been established for hydraulic fluids and greases within the framework of the VAMIL regulation (accelerated depreciation on environmental investments). More than 60 products (mainly hydraulic fluids) meet the VAMIL requirements.

ISO 15380: This International Standard specifies the environmental requirements for environmentally acceptable hydraulic fluids. The ISO 15380 criteria apply to the formulated end-product.

The ecological requirements for these standards cover biodegradability, aquatic toxicity and renewability. NOTE: all the above mentioned schemes include no other production related requirements except the requirement for a certain amount of renewability content.

All schemes, except the Dutch VAMIL regulation and the ISO 15380 for hydraulics set criteria for the different ingredients in the lubricants. The main difference relating to the ecological criteria for lubricants in the different eco-labels concerns the different views on the use of renewable raw materials reflecting different environmental priorities of the countries where the criteria have been developed. Requirements on the content of renewable materials are included in the Swedish Standard for greases (SS 155470 Greases) and the Nordic Swan for lubricating oils.

Establishing an Eco-Label for Biolubricants

Regulation (EC) 1980/2000 of 17 July 2000 on a revised Community Eco-label award scheme established a Community Eco-label award scheme which is intended to promote the design, production, marketing and use of products and services which have reduced environmental impact during their entire life cycle. The criteria are established by product group, using life cycle considerations (LCC).

The European Union Eco-labelling Board (EUEB) has begun work on establishing ecological criteria for the award of the European Eco-label to lubricants.

The EUEB has considered which lubricant applications should be included in the European Eco-label for lubricants. They are assessed according to the following criteria:

- 1) Applications of lubricants included in national eco-labels and international standards which have been successful.
- 2) Loss lubricants and high risk lubricants (i.e. lubricants with a significant environmental impact during use).
- 3) Lubricants with established minimum technical performance criteria. Without such fit for use criteria, false claims for immature products could be made. Fit for use criteria can eliminate this risk.
- 4) Lubricants with a significant market potential if provided as biolubricants.

Based on these criteria:

	Inclusion/ Exclusion	National eco- labels and (inter)national standards	Success of national eco-labels	Loss and high risk lubricants	Technical performance criteria	Market potential bio-variant
Automotive lubricants for passenger cars	Exclude	No		No	Yes	Yes
Two-stroke oils	Include	Yes	No	Yes	Yes	Yes
Hydraulic fluids	Include	Yes	Yes	Yes	Yes	Yes
Chainsaw oils	Include	Yes	Yes	Yes	No	Yes
Compressor oils	Exclude	No		No	Yes	No data
Gear oils	Exclude	Yes	No	No	No data	No data
Greases	Include	Yes	Yes	Many applications	No	Yes
Metalworking fluids	Exclude	Yes	No	No	No	Yes
Concrete release agents	Include	Yes	Yes	Yes	No	Yes
Drilling oils	Exclude	No		Yes	No data	Yes
Lubricants for textile applications	Exclude	No		No	No data	No data
Niche total loss lubricants	Include	No		Yes	Yes for some applications	Yes

The European Eco-label is meant to be Europe's premier award for products which are a genuinely better choice for the environment. In evaluating the comparative improvements, considerations have to be made regarding each life stage of the product. In the case of lubricants that means that the aspect of bio-degradability is not necessary the main criterion. All cradle-to-grave processes should be taken into account, even the pre-production stage of the life cycle, including extraction and processing of raw materials.

The product applications selected as proposed for inclusion in the European Eco-label for lubricants, above, are all loss lubricants which will disappear into the environment during normal use, and high-risk lubricants (hydraulic oils) which are often released into the environment due to accidental releases.

The European Eco-label for lubricants will set criteria that aim in particular:

- a) at promoting the reduction of water and soil pollution and
- b) the savings of exhaustible energy resources.

The environmental criteria are designed to ensure that lubricants qualifying for the European Eco-label and their constituents are biodegradable, exhibit low aquatic toxicity and do not bioaccumulate. The criteria are set out in the boxes below.

The criteria can be seen at the website of The European Union Eco-labelling Board:
http://europa.eu.int/comm/environment/ecolabel/product/pg_lubricants_en.htm

In order to qualify for the European Eco-label, the lubricant subgroups must comply with these criteria, with tests carried out as indicated in the criteria. The criteria proposed here are modelled after the criteria in the Blue Angel, the Nordic Swan and the Swedish Standard. The criteria are designed to reflect the philosophy of the new EU regulatory framework for chemicals (REACH - Registration, Evaluation and Authorisation of Chemicals) and are in line with the Dangerous Substances Directive and Dangerous Preparations Directive.

CRITERIA 1: No R-phrases according to the Dangerous Preparations Directive

The product shall not have any R-phrase indicating environmental and human health hazards according to the Dangerous Preparations Directive (1999/45/EC).

CRITERIA 2: Aquatic Toxicity Requirements

Specific numbers of chemical substances allowed in the end product i.e. the cumulative total of substances exhibiting a certain degree of aquatic toxicity. Evaluated either on the basis of the aquatic toxicity of an additive mixture or on the aquatic toxicity of ingredients.

<i>Aquatic toxicity</i>	Maximum (total) mass percentage of substances present in			
	hydraulic fluids	greases	chain saw oils, concrete release agents and niche loss lubricants	two-stroke oil
10 mg/l < Acute toxicity* ≤100 mg/l or 1 mg/l < NOEC ≤10 mg/l	≤20	<25	≤5	<25
1 mg/l < Acute toxicity* ≤10 mg/l or 0,1 mg/l < NOEC ≤1 mg/l	≤5	≤1	≤0,5	≤1
Acute toxicity* < 1 mg/l or 0,1 mg/l < NOEC < 0, 1 mg/l	≤1	< 0,1	< 0,1	< 0,1

*EC50/LC50/IC50

CRITERIA 3: Requirements for Biodegradability and Bioaccumulative Potential

Biodegradation	Total mass percentage of substances is			
	Hydraulic fluids	greases	chain saw oils, concrete release agents and niche loss lubricants	two-stroke oil
Non-biodegradable *	≤5	≤10	≤5	≤10
Inherently aerobic biodegradable	≤5	≤20	≤5	≤20
Readily aerobic biodegradable	> 90	> 75	> 90	> 75

* Non-biodegradable substances are allowed in the lubricant up to certain percentages as long as they are not at the same time bioaccumulative. In other words non-biodegradable and bioaccumulative substances should not be included in the lubricant.

CRITERIA 4: Exclusion of Specific Substances

Substances appearing in the EU list of priority substances in the field of water policy or the current list of OSPAR (*for the protection of the marine environment of the North-East Atlantic*) List of Chemicals for Priority Action should not be intentionally added as an ingredient in a lubricant eligible for the European Eco-label.

Organic halogen compounds and nitrite compounds should not be added intentionally as an ingredient in a lubricant eligible for the European Eco-label.

Metals or metallic compounds should not be added intentionally as an ingredient in a lubricant eligible for the European Eco-label with the exception of sodium, potassium, magnesium and calcium. In the case of thickeners, lithium and/or aluminium metallic compounds may be used up to concentration limited by the other criteria included here.

CRITERIA 5: Renewable Raw Materials

The carbon content of the formulated product derived from renewable raw material should be at least for:

- Hydraulic oils $\leq 50\%$ (w/w)
- Greases $\leq 45\%$ (w/w)
- Chain saw oils, concrete release agents and niche loss lubricants $\leq 70\%$ (w/w)
- 2-stroke oils $\leq 50\%$ (w/w)

CRITERIA 6: Technical Performance

Hydraulic fluids: have to meet at least the technical performance criteria laid down in ISO 15380, tables 2-5.

Greases: Fit for purpose

Chain saw oils: should meet at least the technical performance criteria laid down in the AFNOR 375-0 certification scheme criteria 7 to 12 or the criteria laid down in the RAL-UZ of the Blue Angel.

Concrete release agents and other total loss lubricants: should be fit for purpose

2-stroke oils: should meet at least the technical performance criteria laid down in “NMMA Certification for Two-Stroke Cycle Gasoline Engine Lubricants” of NMMA TC-W3

CRITERIA 7: Information Appearing on the Eco-Label

Box 2 of the eco-label shall contain the following text: “less harmful for the water and soil; leads to less CO₂ emissions”.

References

- CTVO-Net - Lubricants and Hydraulic Fluids (2000): <http://www.dainet.de/fnr/ctvo>
- European Union Eco-labelling Board (EUEB) – Background Document: Development of Criteria for the Award of the European Eco-label to lubricants (April 2004) and Draft Criteria (July 2004): http://europa.eu.int/comm/environment/ecolabel/product/pg_lubricants_en.htm
- OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic (www.ospar.org)