

# LANXESS

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For further information about Baynox® go to [www.baynox.com](http://www.baynox.com).  
Our patented Baynox® products stand for consistently high quality.

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**BIODIESEL ENERGIZED BY**

**LANXESS**  
Energizing Chemistry

Baynox® extends the shelf life of Biodiesel

**X Baynox®**

## ALTERNATIVE BIOFUELS POWERFUL SOURCE OF GREEN ENERGY

Alternative energy sources are on the rise globally in response to concerns about conventional (fossil) fuel sources and the necessity for environmentally friendly options. Biofuels are fulfilling the demand for a modern, regenerative and low CO<sub>2</sub> emitting fuel. For the transportation sector, bioethanol and biodiesel have become very popular and their use is mandatory in many countries all over the world.

Biodiesel is a renewable fuel derived from vegetable oil or animal fat for combustion in diesel engines. It is made by transesterification of the lipids with methanol and reduces carbon monoxide, particulate matter, sulfur dioxide and aromatic hydrocarbons in exhaust gases. Increasing amounts are used in cars, trucks, buses, off-road vehicles, aircrafts, locomotives, marine vessels as well as stationary power and heat generation.

To meet this demand, a variety of biodiesel grades have been developed and introduced to the market in different blends, ranging from B2 with 2% biodiesel content to B100 with 100% biodiesel. As the quality of the corresponding fuels greatly depends on the origin and process of the biodiesel manufacture, strict quality standards such as EN 14214 and ASTM D6751 have been set-up. These standards guarantee high efficiency and safe operation of the corresponding engines.



## OXIDATION OF BIODIESEL

Despite its many advantages, biodiesel has poor storage stability compared with petro diesel. Ageing arises from the oxidation of unsaturated fatty acid esters, which are present in biodiesel made from vegetable oils, animal fats and used cooking oils. It is initiated by radicals, formed by the interaction of light, oxygen and metal ions with the fatty acid esters, and leads to the formation of volatile free acids and polymers. Acids can corrode both the engine and the fuel injection system. Polymers leads to filter plugging and incomplete combustion.

This process can be visualized by the inflation of a plastic bottle, containing biodiesel and oxygen (air). It can be monitored by the rancimat test, in which an oil sample is heated in a test tube to 110 °C while purging it with a steady stream of air and measuring the degradation products such as volatile organic compounds. The US standard ASTM D6751 requires a minimum stability of 3 hours whereas the European standard EN 14214 demands minimum 8 hours stability.

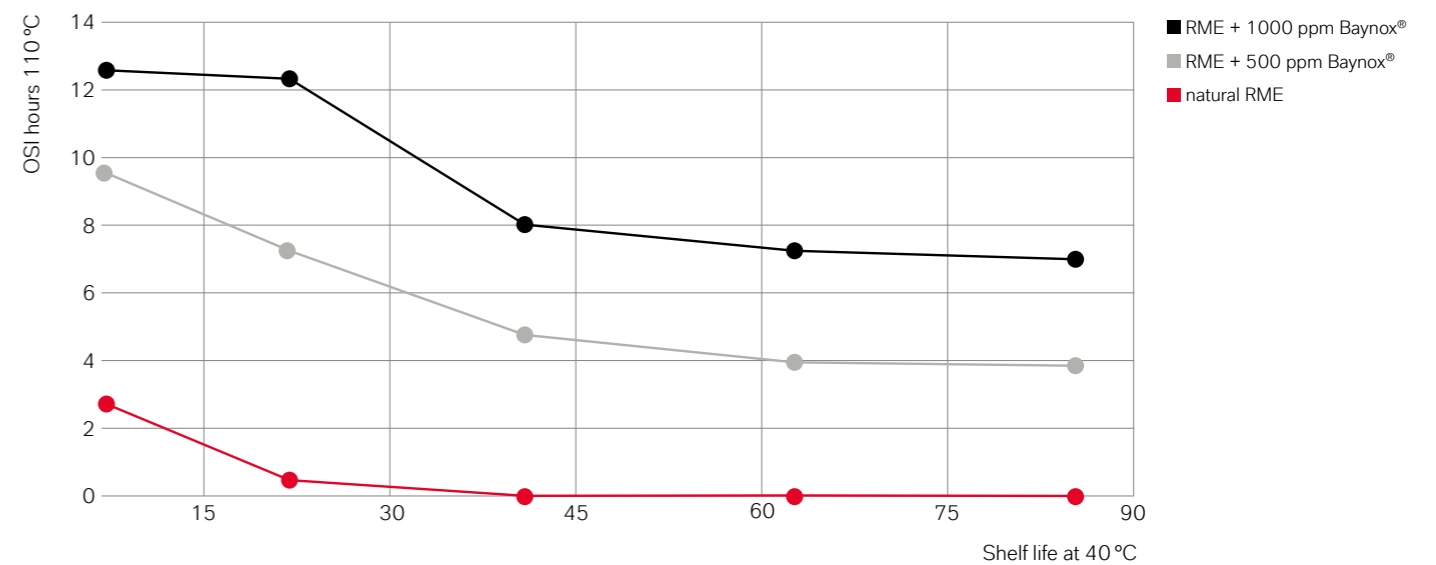
As the stability of biodiesel depends on the origin and purity of the feedstock, the manufacturing processes in the biodiesel plant and on the transportation and storage conditions

(temperature, time, oxygen pressure), the rancimat value can differ widely. In practice, biodiesel grades for B2-B100 blends often do not fulfil these requirements and **this could lead to filter clogging, corrosion, higher fuel consumption and severe engine damage.**

To prevent such damage, it is essential that biodiesel is stabilized by antioxidants. Antioxidants interrupt the oxidation circle by trapping the intermediately formed hydroperoxides. This stops the formation of radicals and the antioxidant is oxidized instead of the biofuel.

Adding oxidation stabilizers increases shelf life and keeps the biodiesel fresh, even when stored for longer periods. In nature, vitamin E works as an antioxidant to protect the oil seeds as long as they are on the plant. Once the oilseeds are harvested, no more vitamin E can be formed and the remaining antioxidant is consumed rapidly. Therefore, synthetic antioxidants have to be added as soon as possible to avoid deterioration of the valuable oils. Once the biodiesel has started to become rancid, the shelf life cannot be improved with further antioxidant addition.

Rancimat curves of natural RME with/without Baynox®



Thermal processes such as transesterification, distillation or usage as cooking oils further accelerate the deterioration of natural vitamin E, making the addition of a synthetic antioxidant even more important.

## SELECTION OF THE RIGHT ANTIOXIDANT

Selecting the right antioxidant depends on the feedstock (vegetable oil, animal fat, used cooking oils), the configuration of the biodiesel plant, the blend rate (B2-B100), the fuel application and the requested rancimat value. In addition to this, the antioxidant must be compatible with biodiesel and petrodiesel, should exhibit good solubility in biodiesel and have a high flash point. Only few synthetic antioxidants can meet these requirements.

From the very beginning, LANXESS has supported the biodiesel industry with dedicated products which are based on sterically hindered phenols. These products, like naturally occurring vitamin E (tocopherol), comprise only carbon, hydrogen and oxygen. In addition to this, we also offer an antioxidant with phenylenediamine as the active element. All these products are non-corrosive and do not contain acids. The same is valid for their solutions in biodiesel, organic solvents and mineral oils.

### Synthetic antioxidants can be classified into four categories:

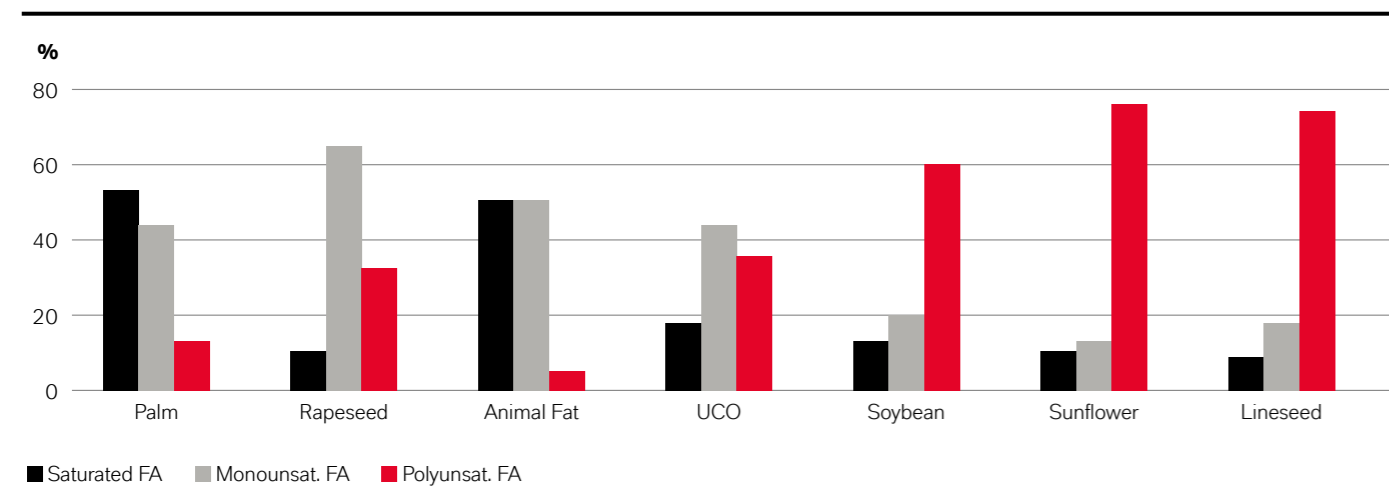
- Category I: sterically hindered monophenols
- Category II: sterically hindered diphenols and triphenols
- Category III: sterically hindered bisphenols
- Category IV: para-phenylenediamines (PPDs)

As a rule, biodiesel with a lower ratio of polyunsaturated oils (iodine numbers <120) can be stabilized with monophenols of category I, whereas for biodiesel with a higher ratio of polyunsaturated oils (iodine number > 120) antioxidants from category II to III are more powerful. PPDs are frequently used for the stabilization of mineral oils and gasoline, but also have a strong effect in biodiesel.

As can be seen from the figure below, palm oil and rapeseed oil can be stabilized more easily than soybean oils and sunflower oils. Though the rule helps to categorize FAME products and find the "right" product category, it cannot predict the type and dosage of the antioxidant. This has to be found out in laboratory trials.

In this context it should also be mentioned that the mode of action can differ widely for the various antioxidants and biodiesel types. The so-called "intrinsic efficacy" describes the relative ability of a given antioxidant-biodiesel-combination to produce the maximum functional response.

### FAME oils and oxidation stability



## SOLID VERSUS LIQUID ANTIOXIDANTS

LANXESS antioxidants can be solids, melts, oils or solutions. Solid stabilizers have proven to be economic and flexible. They can also match a broad application range for biodiesel, blends, kerosene etc. However, the preparation of liquid solutions from solids is not always possible or may require additional investment at the biodiesel plant. Therefore, liquid antioxidants are preferred by an increasing number of users. They should meet the following requirements:

- Concentrated solution with high antioxidant power
- Solvent with high flash point and low pour point
- Stability in biofuel for at least three months
- Complete combustion on ignition, no hazard
- Easy handling, low to medium viscosity, no crystallization



## BAYNOX® ANTIOXIDANTS

LANXESS has developed a series of solid and liquid products of all categories and for a wide range of applications. They have been extensively tested in various biodiesel types and allow for a safe and enduring stabilization of all kind of bio-fuels. These products are grouped into the **Baynox®** product line which has been exclusively created for use in biodiesel, blends and related fuels.

In the following chapters, there are more detailed descriptions of the various products, their typical applications and treat rates in biodiesel.

## BAYNOX® MOLTEN

### Description:

**Baynox®** molten is a colour and odorless liquid which solidifies at temperatures below 70 °C. It belongs to the group of sterically hindered phenols and contains > 99 % active ingredient (2,6-Di-tert-butyl-4-methylphenol).

### Characteristic Data:

Density 20 °C (solid):	1.03 g/cm <sup>3</sup>
Flash point:	127 °C
Boiling point:	265 °C
Solidification point:	68-69 °C
Ash content:	max. 0.002 %

### Application:

**Baynox®** molten is especially suitable for biodiesel produced from vegetable oils with a low content of multiple unsaturated fatty acids and an iodine number <120. It is easily soluble in biodiesel and compatible with common cold filter plugging point (CFPP) improvers. **Baynox®** molten has been awarded "No-harm" status by the German AGQM-Biodiesel Organization.

For use in biodiesel, it is recommended to prepare a stock solution of 15 – 20 wt.-% in biodiesel and add this solution to the final biodiesel. The solution should be kept above 0 °C as crystals may precipitate below this temperature. A minimum of 400 ppm **Baynox®** should be added right from the beginning for all kind of oils to avoid costly engine failures. As the product has a high cost performance relation, it can be used very effectively for RME, PME, most UCOME and animal fats.

### Packaging:

**Baynox®** molten is supplied in heatable road tankers and IBCs. For long term storage at 90 – 100 °C, the tank must have a pressure release valve and should be blanketed with inert gas.

## BAYNOX® EU

### Description:

**Baynox®** EU is a crystalline solid. It belongs to the group of the sterically hindered phenols and contains > 99,8 % active ingredient (2,6-Di-tert-butyl-4-methylphenol).

### Characteristic Data:

Bulk density:	600 – 650 kg/m <sup>3</sup>
Flash point:	127 °C
Melting point:	69 °C
Boiling point:	265 °C
Ash content:	max. 0.002 %

### Application:

**Baynox®** EU is especially suitable for biodiesel produced from vegetable oils with a low content of multiple unsaturated fatty acids and an iodine number <120. It is easily soluble in biodiesel and compatible with common CFPP improvers. **Baynox®** EU has been awarded "No-harm" status by the German AGQM-Biodiesel Organization.

For use in biodiesel, it is recommended to prepare a stock solution of 15 – 20 wt.-% in biodiesel and add this solution to the final biodiesel. The solution should be kept above 0 °C as crystals may precipitate at lower temperatures. A minimum of 400 ppm **Baynox®** EU should be added right from the beginning for all kind of oils to avoid costly engine failures. As the stability of FAME can differ a lot, treat rates of up to 1000 ppm or even more may be necessary for "difficult" biodiesel. **Baynox®** EU can be used very effectively for RME, PME, most UCOME and animal fats.

### Packaging:

**Baynox®** EU is supplied in 25 kg paper bags and 500 kg bigbags.



## BAYNOX® PLUS

### Description:

Baynox® plus is a white to pale coloured powder. It belongs to the group of sterically hindered bisphenols and contains >96 % active ingredient. Due to its special chemical structure, Baynox® plus is a much stronger antioxidant and has a better heat resistance than Baynox® EU and other monophenols.

### Characteristic Data:

Bulk density:	320 kg/m <sup>3</sup>
Flash point:	185 °C
Melting point:	124 °C
Boiling point (0,07 hPa):	186 °C
Ash content:	max. 0.1 %

### Application:

Baynox® plus has a much stronger antioxidant activity and is particularly suitable for the stabilization of oils with a high degree of double and triple unsaturated acids like soy, sunflower, linseed and jatropha oils. It is easily soluble in biodiesel and compatible with common CFPP improvers. Baynox® plus has been awarded "No-harm" status by the German AGQM-Biodiesel Organization.

For use in biodiesel it is recommended to prepare a stock solution of 15 – 20 wt.-% in biodiesel and add this solution to the final biodiesel. The solution should be kept above 0 °C as crystals may precipitate at lower temperatures. With a dosage of 300-500 ppm, rancimat values of min. 9 hours can be achieved in most biodiesel types. Baynox® plus can be used for long-term stabilization of biodiesel in marine vessels and power generators.

### Packaging:

Baynox® plus is supplied in 15 kg paper bags.



## BAYNOX® 44PD

### Description:

Baynox® 44PD is a dark brown liquid which solidifies at temperatures below 17 °C. It belongs to the group of the phenylenediamines and contains >96 % active ingredient (N,N'-di-sec-butyl-p-phenylenediamine).

### Characteristic Data:

Density 16°C (solid):	0.94 g/cm <sup>3</sup>
Flash point:	140 °C
Boiling point:	310 °C
Solidification point:	17 °C
Ash content:	max. 0.1 %

### Application:

Baynox® 44PD is suitable for most kinds of diesel, biodiesel and blends thereof. It is also suitable for gasoline. Baynox® 44PD has been awarded "No-harm" status by the German AGQM-Biodiesel Organization.

For use in biodiesel, it is recommended to prepare a stock solution of 15 – 20 wt.-% in biodiesel and add this solution to the final biodiesel. The pure product needs to be heated in winter time to avoid solidification. A minimum of 400 ppm Baynox® 44PD should be added right from the beginning for all kind of oils to avoid costly engine failures. The antioxidant can also be used for long-term stabilization of biodiesel in marine vessels, military storages and power generators. It can also be used in combination with Baynox® EU.

### Packaging:

Baynox® 44PD is supplied in road tankers and 200 L-drums.



# BAYNOX® FORMULATIONS

LANXESS has developed formulations of various antioxidants in biodiesel and organic solvents. Depending on the type and content of the antioxidant, the products provide medium to very strong activity in biodiesel. LANXESS offers formulations for all types of biodiesel, to facilitate transportation, handling and dosage at the biodiesel plant or in the tank terminals.

In the following chapters, there are more detailed descriptions of the various products, their typical applications and treat rates in biodiesel.

## BAYNOX® SOLUTION

### Description:

Baynox® Solution is a ready to use 20 % solution of Baynox® in biodiesel. It is a clear, yellow to brownish liquid.

### Characteristic Data:

Density 20 °C:	0.892 g/cm <sup>3</sup>
Flash point:	147 °C
Cloud point:	-16 °C
Viscosity kinem. (20 °C)	10 mm <sup>2</sup> /s
Ash content:	max. 0.02 %

### Application:

Baynox® Solution is particularly recommended for biodiesel from vegetable oils with a low content of multiple unsaturated fatty acids and an iodine number of < 120. It is easily soluble in biodiesel and compatible with common CFPP improvers. Baynox® Solution has been awarded "No-harm" status by the German AGQM-Biodiesel Organization.

The solution should be kept above 0 °C as crystals may precipitate below this temperature. A minimum of 1500 ppm Baynox® Solution should be added right from the beginning for PME, RME, most UCOME and animal fats to avoid costly engine failures. For biodiesel which is stored over long periods, such as for heating oil, emergency generators or marine diesel, higher treat rates are recommended. The exact figure is highly dependent on the application and has to be determined in laboratory trials.

### Packaging:

Baynox® Solution is supplied in 20 m<sup>3</sup> road tankers and IBCs. The storage of Baynox® Solution can be stored in tanks which are of the same material and standard as tanks for biodiesel itself.

## BAYNOX® PLUS SOLUTION

### Description:

Baynox® plus Solution is a ready to use 20 % solution of Baynox® plus in biodiesel. It is a clear, yellow to red liquid.

### Characteristic Data:

Density 20 °C:	0.89 g/cm <sup>3</sup>
Flash point:	180 °C
Cloud point:	-16 °C
Viscosity kinem. (20 °C)	10 mm <sup>2</sup> /s
Ash content:	max. 0.02 %

### Application:

Baynox® plus Solution is especially suitable for biodiesel from vegetable oils with a high content of multiple unsaturated fatty acids and an iodine number of > 120, such as soy, jatropha oil and others. It is easily soluble in biodiesel and compatible with common CFPP improvers.

The solution should be kept above 0 °C as crystals may precipitate below this temperature. A minimum of 1500 ppm Baynox® plus Solution should be added right from the beginning for SME, SFME, jatropha and linseed oils to avoid costly engine failures. For biodiesel which stored over long periods, such as for heating oil, emergency generators or marine diesel, higher treat rates are recommended. The exact figure depends to a large extent on the application and has to be determined in laboratory trials.

### Packaging:

Baynox® plus Solution is supplied in 20 m<sup>3</sup> road tankers and IBCs. Baynox® plus Solution can be stored in tanks which are of the same material and standard as tanks for biodiesel itself.



## BAYNOX® CARGO

### Description:

Baynox® Cargo is a ready to use 34 % solution of Baynox® in mineral oil. It is a clear to yellowish liquid which remains liquid down to -5 °C.

### Characteristic Data:

Density 20 °C:	0.905 g/cm <sup>3</sup>
Flash point:	64 °C
Viscosity kinem. (20 °C):	5 mm <sup>2</sup> /s
Ash content:	max. 0.002 %

### Application:

Baynox® Cargo is particularly recommended for biodiesel from vegetable oils with a low content of multiple unsaturated fatty acids and an iodine number of < 120. It is easily soluble in biodiesel and compatible with common CFPP improvers.

A minimum of 600–1200 ppm Baynox® Cargo should be added right from the beginning for PME, RME, most UCOME and animal fats to avoid costly engine failures. For biodiesel which is stored over long periods, higher treat rates are recommended. The exact figure is highly dependent on the application and has to be determined in laboratory trials.

### Packaging:

Baynox® Cargo is supplied in 20 m<sup>3</sup> road tankers and IBCs. The storage of Baynox® Cargo can be stored in tanks which are of the same material and standard as tanks for biodiesel itself.



## BAYNOX® ULTRA

### Description:

Baynox® Ultra is a new oxidation stabilizer which contains a balanced blend of strong to very strong antioxidants (category II + III) in an environmental friendly “green” solvent. Moreover, it contains a neutral metal chelator which is not corrosive and allows for a low acid number. The amber coloured liquid is the strongest liquid product of the Baynox® family and has a high activity at low dosage. Despite an antioxidant concentration of more than 40 wt-% the solution remains clear at temperatures down to -5 °C.

### Characteristic Data:

Density 20 °C:	1.050 g/cm <sup>3</sup>
Flash point:	140 °C
Cloud point:	-25 °C
Viscosity kinem. (20 °C):	90 mm <sup>2</sup> /s
Ash content:	max. 0.02 %

### Application:

Baynox® Ultra is especially suitable for biodiesel produced from vegetable oils with a medium to high content of multiple unsaturated fatty acids and iodine numbers of > 120, such as soybean and sunflower oils but also certain types of used cooking oils. It is easily soluble in biodiesel and compatible with common CFPP improvers. Baynox® Ultra has been awarded “No-harm” status by the German AGQM-Biodiesel Organization.

As the product is highly active, low treat rates of 100 to 400 ppm Baynox® Ultra are sufficient in most cases to avoid costly engine failures. For biodiesel which are highly unstable, e.g. SFME and linseed oil, higher treat rates are recommended. The exact figure depends considerably on the application and has to be determined in laboratory trials.

### Packaging:

Baynox® Ultra is supplied in 200 L-drums and IBCs. Baynox® Ultra can be stored in tanks which are of the same material and standard as tanks for biodiesel itself.

## APPLICATION AND DOSING RECOMMENDATIONS



ANTIOXIDANT	TYPE	TREAT RATE*
<b>LOWLY UNSATURATED</b>		
<b>PALM OIL</b>		
Baynox® EU	Solid	200–400 ppm
Baynox® Solution	Solution	1000–2000 ppm
Baynox® Cargo	Solution	600–1200 ppm
<b>RAPE/CANOLA OIL</b>		
Baynox® molten	Liquid	400–600 ppm
Baynox® EU	Solid	400–600 ppm
Baynox® 44PD	Liquid	300–500 ppm
Baynox® Solution	Solution	2000–3000 ppm
Baynox® Cargo	Solution	1200–1800 ppm
Baynox® Ultra	Solution	100–300 ppm
<b>USED COOKING OILS</b>		
Baynox® EU	Solid	200–600 ppm
Baynox® Solution	Solution	1000–3000 ppm
Baynox® Ultra	Solution	100–300 ppm
<b>ANIMAL FAT</b>		
Baynox® EU	Solid	300–500 ppm
Baynox® Solution	Solution	1500–2500 ppm
Baynox® Cargo	Solution	1500–2500 ppm
<b>HIGHLY UNSATURATED</b>		
<b>SOYBEAN OIL</b>		
Baynox® plus	Solid	300–500 ppm
Baynox® 44PD	Liquid	500–700 ppm
Baynox® plus Solution	Solution	1500–2500 ppm
Baynox® Ultra	Solution	200–400 ppm
<b>SUNFLOWER OIL</b>		
Baynox® plus	Solid	400–600 ppm
Baynox® plus Solution	Solution	2000–3000 ppm
Baynox® Ultra	Solution	300–700 ppm
<b>LINSEED / FISH OIL</b>		
Baynox® plus Solution	Solution	> 3000 ppm
Baynox® Ultra	Solution	> 1000 ppm

\* Treat rates (guideline) for untreated oils to achieve 8 hrs. rancimat. The exact figure depends on the application and has to be determined in laboratory trials.

# QUALITY IN THE BIOFUEL TANK

To get high quality biodiesel products into millions of tanks, the quality has to be assured along the whole supply chain.

Different quality standards and regulations are in place, reflecting the various base oils, production processes and usages in the various countries. In Europe, the biodiesel standards EN90, DIN 51628 and EN 14214 recommend antioxidant dosages of 200 to 1000 ppm BHT or BHT equivalent. The French B7 specification requests a minimum stabilization of 1000 ppm BHT. In the USA, the relevant standards are ASTM D7467 for B6-B20 and ASTM D6751 for B100.

For marine and aviation usage, industry-special standards exist, also for heating oil which applies modified standards from biodiesel or separate standards such as DIN V 1603-6 and EN 14213.

LANXESS has been active in the development of various standards for biodiesel and **Baynox®** has become the gold standard for many applications. It is also the reference product for the internationally accepted no-harm list from the German "AGQM-biodiesel" organization.

To support the high quality requirements of the biodiesel industry, LANXESS only produces purified distilled products for use in biodiesel and exclusively sells these products under the **Baynox®** brand. The active ingredients are chemically well defined, are not corrosive and combust completely on ignition.

LANXESS offers technical support and free stability tests with biodiesel samples. We help our customers to find the best and most economic strategy for stabilizing biodiesel in production and distribution.

LANXESS has supported the biodiesel industry from the very beginning. Through our long-term, well-established partnership with institutes, universities, producers, engineering companies and market participants, we have in-depth expertise of biodiesel stabilization.

## BAYNOX® AT A GLANCE

- **Baynox®** is the gold standard for all biodiesel qualities, it shows outstanding performance in low dosage and effectively extends the shelf life
- **Baynox®** is the reference product and is no-harm certified by AGQM-biodiesel
- **Baynox®** is easily soluble in all types of biodiesel and mineral oils
- **Baynox®** prolongs the shelf life of biodiesel along the whole supply chain
- **Baynox®** has a flash point > 60°C, it combusts completely on ignition
- **Baynox®** allows for a broad application range from petrodiesel to most Biodiesel types and even heating oil.

For further information about **Baynox®** go to [www.baynox.com](http://www.baynox.com)

