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ANTIOXIDANTS AND ACCELERATORS (AXX) PORTFOLIO 2016-02

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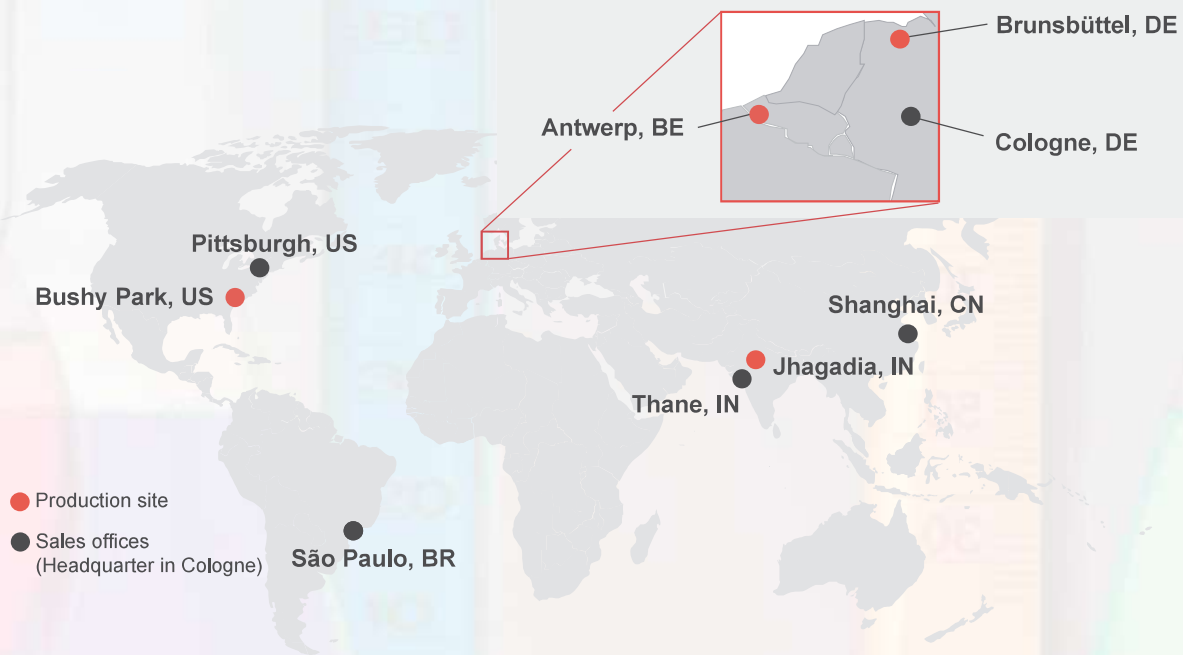
LANXESS - THE SUCCESSFUL HISTORY IN RUBBER CHEMICALS

From the days of the invention of synthetic rubber until today, our predecessor company and LANXESS have been driving the rubber market. Based on our long term experience in the rubber industry, we are able to offer products throughout our portfolio with a superior quality level. This reliability is also well recognized by our non rubber customers.

Our rubber competence is part of the extensive LANXESS portfolio, which focusses on premium products. Its core business comprises the development, manufacture and sale of high-tech plastics, high-performance rubber, specialty chemicals and intermediates. In addition, it helps its customers in the development and implementation of individual system solutions. In these areas, which are at the very core of the chemical industry, the Group has specific expertise in the form of chemical and application-related know-how and flexible asset management. The Group's aim is, through innovative products, optimized processes and new ideas, to generate added value for customers and the company.

Long term partner for the industry

The business unit Advanced Industrial Intermediates (AII) from LANXESS is committed to the rubber industry. Our vision is to establish a long term relationship with our customers by offering more than just products. Based on a long history our business unit is continuously working on innovative products and solutions. Even though the rubber world is our background, our focus is much wider.



ADVANCED INDUSTRIAL INTERMEDIATES

Market Focus, Quality and high level of Expertise

The LANXESS Business Unit Advanced Industrial Intermediates (All) is known for high quality industrial chemicals. A broad range of products is providing the prerequisite for our customers success.

In four business lines, "Benzyl Products and Inorganic Acids", "Polyols and Oxidation Products", "Aromatic Network" and „Antioxidants and accelerators", we combine long standing production excellence with customer partnership. Strict market focus as well as market knowledge are laying out our road of success.



COMPETENCE LEADS TO SUSTAINABLE DEVELOPMENT

We offer our products at most advanced levels

Our products have been investigated applying the latest methods for risk assessment. Our material safety data sheets provide all the information needed to handle and apply our products safely.

Our processes are designed to minimize impacts on air, water and soil because of our up-to-date installations. Responsibility is part of our daily operation. Our neighbour is our partner.

Regular process safety studies, combined with continuous investments into safety installations are providing our backbone for plant and transportation safety. Regular inspections prove our concept.

Our products are of high quality. Our manufacturing processes yield products of consistent quality for our customers. We have the know how to transport hazardous goods globally, on time, in full.

If our products and services do not fulfil customers' expectations, we investigate and respond.

Our assets are maintained for long-term operation. Maintenance leads to high asset reliability with the most advanced technical standards.

Our personnel are well trained and their knowledge and skills contribute to our business. Our vendors and service providers must fulfil all our expectations.

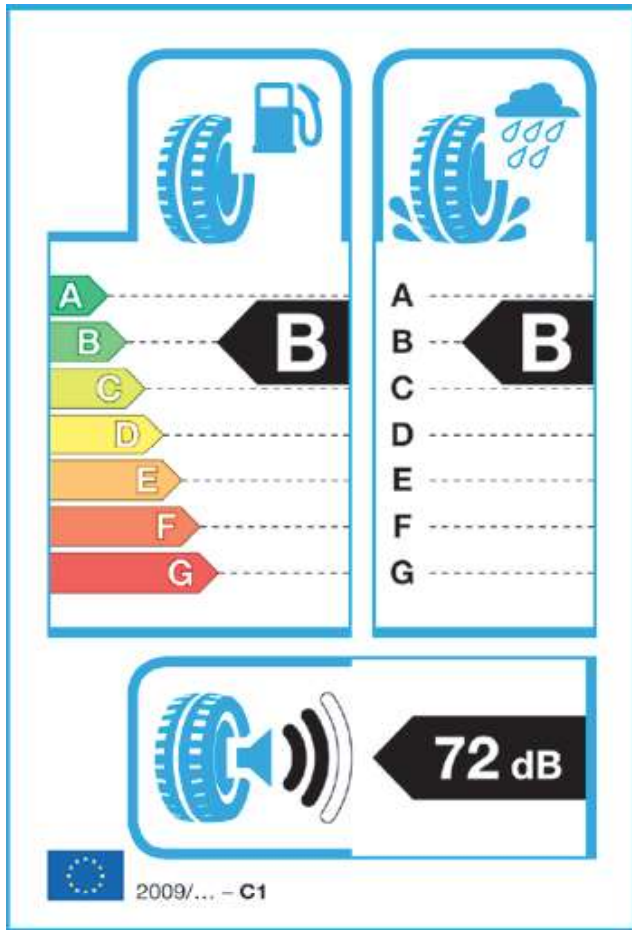
REACH means responsible action: We strive to minimize the risks for a set of enumerated uses as set out in our material safety data sheets.

We are committed to Product Stewardship and Responsible Care Initiatives, including the European REACH legislation.

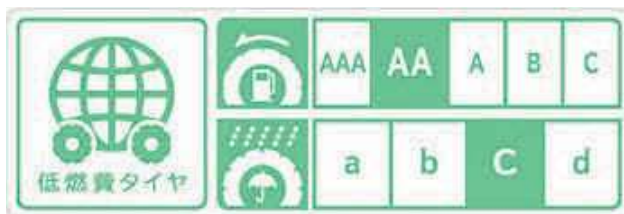
Sustainable Development – Compliance – Ethical Standards



HIGH PERFORMANCE ADDITIVES FOR GREEN TIRES



■ The label makes important characteristics of the tire visible.



■ Japanese tire label introduced in 2011



■ South Korean version introduced in 2012

Essentially, Green Tires are made possible through the use of technically advanced polymers and rubber chemicals, such as that which LANXESS supplies throughout the tire industry. Numerous types of materials are compounded into a tire with one goal; the tire must ultimately achieve top grades in the most important disciplines – wet grip, tire noise and fuel-efficiency.

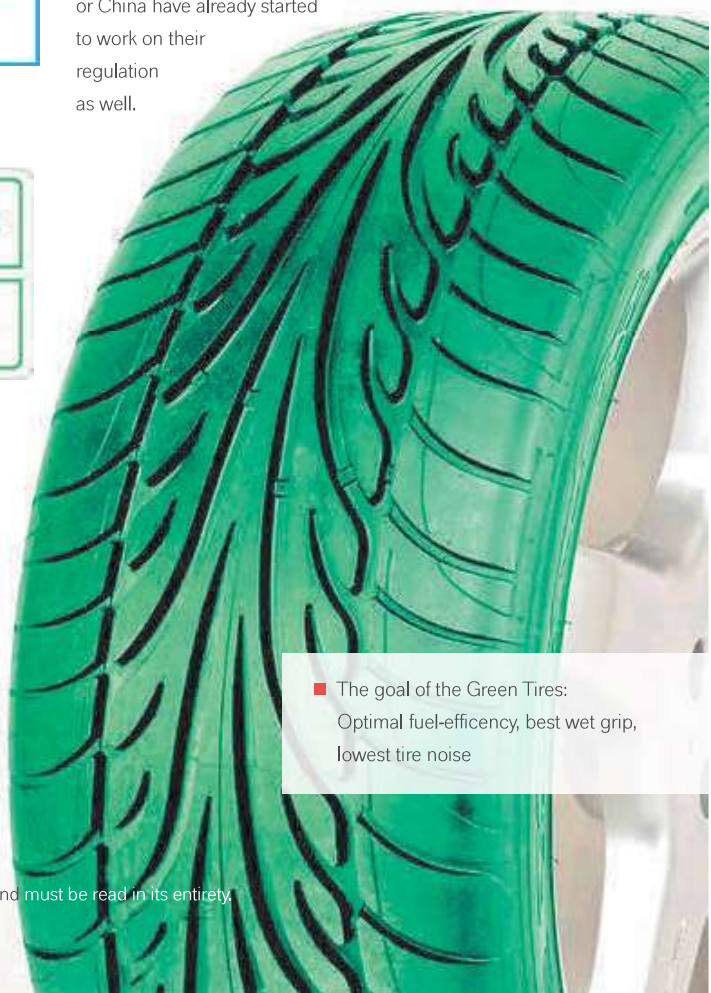
Tire labeling makes differences visible

Until now these quality 'grades' of the tires could not be seen by the customer – a shortcoming which was corrected by the EU-wide compulsory tire labeling. Standardized labeling, which the European Commission introduced in the end of 2012, provides information on three key tire performance qualities: fuel consumption, wet grip and rolling noise.

There are seven hierarchical grades from A to G. Similar to the energy classes on refrigerators, there is now also a clear labeling on tires, from A to G, signaling to which quality class a product belongs.

Tires that offer particularly low rolling resistance and thus lower fuel consumption receive the top grade: A. As a result of the label, a customer can immediately tell how "green" his tires really are when making a purchase. The new EU regulations aim to improve energy efficiency and safety standards of future tires. It enables consumers to make informed purchasing decisions.

Beside the EU other countries such as South Korea or Japan introduced a similar tire label. Countries such as Brasil, the United States or China have already started to work on their regulation as well.



■ The goal of the Green Tires:
Optimal fuel-efficiency, best wet grip,
lowest tire noise

TIRE APPLICATIONS

	International abbreviation	High performance silica	Passanger car carbon black	Light truck	Heavy truck	Earth mover	Tread	Subtread	Sidewall	Cord adhesion
Rubber chemicals										
Merkapto accelerators										
Vulkacit® Merkapto	MBT	■	■	■	■	■	■	■	■	■
Vulkacit® DM	MBTS	■	■	■	■	■	■	■	■	■
Sulfenamide accelerators										
Vulkacit® CZ	CBS	■	■	■	■	■	■	■	■	
Vulkacit® NZ	TBBS	■	■	■	■	■	■	■	■	
Vulkacit® DZ	DCBS									■
Staining antioxidants with antiozonant effect										
Vulkanox® 4010	IPPD	■	■	■	■	■	■	■	■	
Vulkanox® 4020	6PPD	■	■	■	■	■	■	■	■	
Vulkanox® 4030	77PD	■	■	■	■	■	■	■	■	
Staining antioxidant										
Vulkanox® HS	TMQ	■	■	■	■	■	■	■	■	■
Non staining antiozonants										
Vulkazon® AFS		■	■						■	
Peptizing agents										
Renacit® 10	DBD	■	■	■	■	■	■	■	■	■
Renacit® 11	DBD	■	■	■	■	■	■	■	■	■

WIDE RANGE OF PREMIUM PRODUCTS FOR TECHNICAL RUBBER GOODS

LANXESS has driven innovation in the rubber industry since the days of the invention of synthetic rubber. Over decades LANXESS has developed a broad spectrum of rubber polymers as well as rubber chemicals. This range includes all major polymers and rubber chemicals used in tire and automotive technology, and also additional specialties for technical rubber goods. Our broad portfolio of high quality rubber chemicals helps our customers meet their individual performance requirements.

Our complete portfolio consists of accelerators, antioxidants and mastication agents. Our range of products is designed to meet the demand of our customers today.

Non-staining and chemically effective antiozonants and **Vulkazon® AFS**, cyclic acetal, can be used in white, grey and colored technical rubber goods. A further advantage of **Vulkazon® AFS** is that it does not affect the peroxide curing used for the polymerization of elastomers with a saturated backbone.

A special quality of **Vulkanox® HS** was developed for the application in semi conductive layers of medium to high voltage cables. Our "salt free" quality ensures that the water permeability is significantly lower compared to standard competitive grades.

You will find an overview on our product portfolio and its applications on the following pages, for further information on our products, please contact your local sales representative.

Vulkacit®

Vulcanization is the conversion of a high-molecular material from the plastic to the elastic state. One of the key chemical reactions in this process is that of rubber with sulfur. Sulfur vulcanization, widely used in the rubber industry, requires the use of vulcanization accelerators such as **Vulkacit®**.

Vulcanization accelerators are not catalysts because they are part of the chemical reaction. The great variety of accelerators available is a result of their different influences on the vulcanization kinetics (scorch and cure time) and on physical properties such as tensile strength, elasticity or resistance to aging. In many cases, accelerators are combined to supply optimal processing and physical properties.

Key Properties

- Mercapto accelerators
very fast accelerators giving a very broad plateau and good aging resistance.
- Sulfenamide accelerators
fast but very safe accelerators providing a steep slope on the rheometer curve.

Vulkanox®

Aging processes, which are caused by oxygen or heat, change the properties of the vulcanizates. Rubbers generally are subject to such changes that occur in the course of time and can lead to partial or complete destruction. Possible consequences are depolymerization, fatigue, brittleness, cracks and even disintegration. The resistance of a rubber article to oxygen, ozone and other reactive substances is determined mainly by the elastomer on which the compound is based and by the chemicals that are added to retard the destructive processes.

Unsaturated groups in the rubber molecule are the reason for the rubber's sensitivity to oxygen, which increases with temperature. If catalysts of oxidation (known as rubber poisons) are present, aging is rapid. The results are hardening and embrittlement, crazing effects and fatigue. Ozone or dynamic stress (fatigue) lead to cracking on the surface of the rubber article.

Antidegradants such as **Vulkanox®** are chemicals which protect the vulcanizates against damaging external influences. Depending on the chemical structure, they act against one or more of the aging processes mentioned. None of the antidegradants is universally effective, each has a definite spectrum of activity and characteristic effectiveness, and a definite propensity to discolor the goods if they are exposed to light. Staining antidegradants are generally more effective than non-staining ones.

Key Properties

- protection against oxidation, ozone, heat and rubber poisons
- protection against dynamic stress

Renacit®

Natural rubber is masticated to improve processing. By breaking down the molecular chain the polymer viscosity is reduced. This is usually achieved by mechanical forces in a mixer, which consumes energy. The higher the temperature, the faster the mastication. **Renacit®** mastication agents decrease the mastication time, and therefore the dump temperature, by a special chemical process. Hence, less power is consumed, mixer capacity is increased and costs are reduced. **Renacit®** is very efficient: only a very small amount is required.

Key Properties

- reduction of mastication times
- very efficient
- cost savings, energy savings

RUBBER CHEMICALS PORTFOLIO FOR TECHNICAL RUBBER GOODS

Rubber chemicals	Int. abb.	NR/IR	BR	CR	CSM	EPDM	EPM	EVA	HNBR	NBR	HIIR	IIR	SBR
Merkapto accelerators													
Vulkacit® Merkapto	MBT	■	■	■	■	■			■	■	■	■	
Vulkacit® ZM	ZMBT	■											
Vulkacit® ZM-2	ZMBT	■											
Vulkacit® DM	MBTS	■	■	■	■	■			■	■	■	■	
Sulfenamide accelerators													
Vulkacit® CZ	CBS	■	■			■			■	■		■	■
Vulkacit® NZ	TBBS	■	■			■			■	■		■	■
Vulkacit® DZ	DCBS	■	■			■			■	■		■	■
Staining antioxidants with antiozonant effect													
Vulkanox® 4010	IPPD	■	■						■	■			■
Vulkanox® 4020	6PPD	■	■						■	■			■
Vulkanox® 4030	77PD	■	■						■	■			■
Staining antioxidant													
Vulkanox® HS	TMQ	■	■	■		■	■		■	■	■	■	■
Non staining antioxidants													
Vulkanox® SP*	SPH	■		■		■			■	■	■		
Vulkanox® MB2	MMBI	■		■		■	■		■	■	■		
Vulkanox® ZMB2	ZMMBI	■		■		■	■		■	■	■		
Non staining antiozonants													
Vulkazon® AFS		■	■	■					■	■			■
Peptizing agents													
Renacit® 10	DBD	■											
Renacit® 11	DBD	■											

* marketed only outside the EU



LATEX APPLICATIONS

LANXESS is a globally operating supplier of latex chemicals for the latex processing industry with a broad product range, tailored to meet the requirements of a wide variety of applications.

Several generations of latex specialists

In latex processing LANXESS can look back on a long history of achievement. Important milestones include the first patent for synthetic latex in 1912 and the development of thiazoles and dithiocarbamates as accelerators, which are particularly suitable for the manufacture of dipped and molded articles. Further landmarks were innovations in an important class of zinc oxides, and in colloidal sulfur, antioxidants and special-purpose latex chemicals.

Expertise at every level

This considerable experience is one of the reasons why LANXESS has become one of the most important partners of the latex processing industry. Others include the high quality of the products, which is assured through internal and external quality management systems, the high reliability of delivery ensured through in-house production and a worldwide service network, enabling LANXESS to provide individual on-site support for specific issues concerning latex.

Please find below information on our portfolio of latex chemicals. For further or more detailed information e.g. on food contact applications please do not hesitate to contact our local experts. You will find their addresses at the end of this brochure.

Know-how for your products

Whatever your application is, chemicals experts at LANXESS will provide individual technical advice tailored to your needs. We are aiming to optimize applications for individual customers by modifying products or formulations.

Examples of solutions

For producers of rubber threads, for example, a special formulation of the accelerator ZMBT containing only a small amount of free MBT has been developed.

Due to its structure, MBT can cause breakage in fine rubber threads. By reducing the free MBT content we have managed to improve the quality and reduce the number of rejects. The following pages illustrate further examples.

Latex applications


Latex chemicals	International abbreviation	Coagulated goods							Foams		Shoes				Automotive			
		Examination gloves	Surgical gloves	Household gloves	Industrial gloves	Balloons	Condoms	Latex threads	Foam mattresses	Carpet foams	Artificial leather	Shoe inner soles	Adhesives	Leather crumbs	Gaskets	Tire cords	Rubberized hairs	Wiping cloths
Accelerators NaMBT Solution	NaMBT				■			■										
Antioxidants Vulkanox® SP* Vulkanox® MB2/MG Vulkanox® ZMB2/C-5 Vulkanox® HS	SPH MMBI ZMMBI TMQ	■	■	■	■			■	■	■	■		■	■	■	■	■	■

* marketed only outside the EU

LATEX FORMULATION GUIDELINE

Property required	Latex types	End product	Crosslinking vulcanization	Chemicals
High elasticity	Natural latex (NR)	Examination gloves Surgical gloves Balloons, Condoms	Vulcanization paste	Vulkacit® ZM-2, Vulkanox® MB2/MG
High elasticity	Natural latex (NR)	Rubber threads	Vulcanization paste	Vulkacit® ZM-2
Low permeability	Nitrile latex (NBR)	Surgical gloves Industrial gloves	Vulcanization paste	Vulkacit® ZM-2
Low swelling	Nitrile latex (NBR)	Gaskets	Vulcanization paste	Vulkacit® ZM, Vulkanox® SKF*
High elasticity	Natural latex (NR)	Mattresses	Vulcanization paste	Vulkacit® ZM, Vulkanox® BKF, Vulkanox® SKF*
Foamability, mechanical stability	Styrene-butadiene latex (SBR)	Carpet backing	Vulcanization paste	Vulkacit® ZM, Vulkanox® HS
Abrasion resistance	Nitrile latex (NBR)	Artificial leather Industrial gloves	Vulcanization paste	Vulkacit® ZM, Vulkanox® SKF*
Washability	Nitrile latex (NBR)	Wiping cloth	Vulcanization paste	Vulkacit® ZM
Stiffness	Styrene-butadiene latex (SBR)	Toe caps	No paste	—
Good bonding	Chloroprene latex (CR)	Inner soles	Vulcanization paste	Vulkanox® BKF
Flexibility	Natural latex (NR)	Leatherboard	Vulcanization paste	Vulkacit® ZM, Vulkanox® SKF*
Oil resistance	Nitrile latex (NBR)	Industrial gloves	Vulcanization paste	Vulkacit® ZM, Vulkanox® SKF*
Ozone resistance	Chloroprene latex (CR)	Weather balloons	Vulcanization paste	Vulkanox® BKF, Vulkanox® MB2/MG
Permeability	Chloroprene latex (CR)	Gloves	Vulcanization paste	Vulkanox® BKF
	Chloroprene latex (CR)	Inner soles	Vulcanization paste	Vulkanox® BKF

* marketed by LANXESS Distribution



TAILOR MADE SOLUTIONS FOR VARIOUS APPLICATIONS

Based on the long history in the production of high performance chemicals, today LANXESS business unit Advanced Industrial Intermediates (AII) is offering a wide portfolio of additives and intermediates to numerous industries. In addition, our portfolio contains certain special grades of products, tailor made for specific applications.

■ Products of our portfolio: proven in use for the production of precious metals

Merkapto products for pharma and agro applications

With its nitrogen and sulphur functionality, **Vulkacit® Merkapto** is a very versatile molecule and used across several industries. Mercaptobenzothiazole (MBT) as well as benzothiazole (BT) are important intermediates in the synthesis of several active ingredients such as for pharmaceutical and agricultural use.

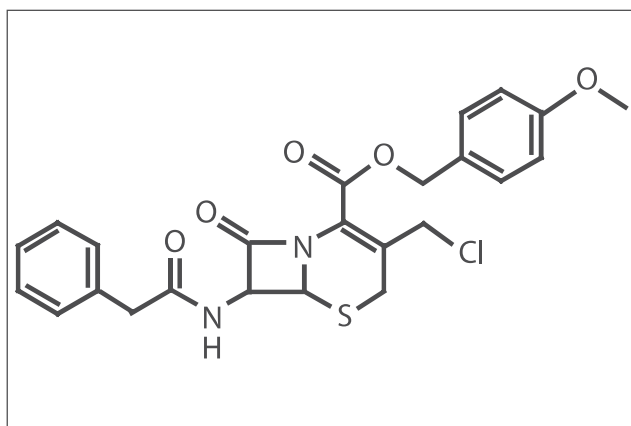
For example in the production of 3rd and 4th generation of cephalosporin antibiotics MBT is used in the synthesis of the intermediate GCLE based on penicillin G. The synthesis route via GCLE offers several advantages compared to other routes like

- higher recovery yield
- simple process
- cost advantage

Vulkacit® Merkapto is available from LANXESS in several pharma qualities, higher than 99% HPLC purity grade.

For cephalosporin synthesis based on MICA acid as raw material, **Vulkanox® DM** (MBTS) is used as a protection group.

Also **Vulkanox® MB-2** has a merkapto functionality that makes it a versatile building block in organic chemical synthesis. It is used as an intermediate to manufacture generic proton-pump inhibitors (PPI) as Lanzoprazole and Rabeprazole. These PPI's are slowing or preventing the stomach's productions of gastric acids.



■ Synthesis of antibiotics intermediate GCLE is based on MBT

Mercaptobenzothiazole products in froth flotation

Flotation is a separation process that clarifies a water phase by the removal of suspended matter such as oil or solids. The removal is achieved by dissolving air in the water or waste water under pressure and then releasing the air at atmospheric pressure in a flotation tank or basin. The released air forms tiny bubbles which adhere to the suspended matter causing it to float to the surface of the water where it may then be removed by a skimming device. Flotation is very widely used in treating the industrial waste water from oil refineries, petrochemical and chemical plants, natural gas processing plants, and paper mills.

The chemical functionality makes MBT an excellent flotation agent used in the processing of mineral ores. MBT gets ionized in alkaline media and consists of a neutral (-hydrophobic) part and an ionic part. In NaMBT, the MBT is already ionized. The ionic part will cover ionic parts as metals, whereas the hydrophobic part will bond to hydrophobic gas bubbles. The gas bubbles used in flotation processes will float these up.

Vulkacit® Merkapto and sodium mercaptobenzothiazole from LANXESS are excellent collectors for the flotation of many precious metals like gold, lead, molybdenum, platinum, silver, copper, nickel and zinc.



■ Froth flotation as a process to collect certain metals from mineral ores

Corrosion inhibitors based on mercaptobenzothiazole products

The amphiphilic character of NaMBT helps to prevent corrosion in all types of water circuits. With its ionic part the molecule is bonding to the metal surface, covering it and forming a film layer. As this layer is hydrophobic, the water is repelled from the metal surface.

Sodium MBT from LANXESS is used in cooling circuits of power plants as well as under acidic condition (high load of hydrogensulfide) in for example gas compression units.

- Chemical plants, power plants - typical fields of operation for NaMBT from LANXESS in water circuits



Mercaptobenzothiazole products for biocides

Mercaptobenzothiazole and its sodium salt are the major raw materials for the synthesis of 2-(thiocyanomethylthio) benzothiazole (TCMTB,). TCMTB is a micro biocide, an active ingredient of fungicides and an antifouling agent used as a substitute for chlorophenols in industrial applications.

- MBT as raw material for leather protection



Vulkanox® additives for fuel and oil applications

Vulkanox® 4005 is used at different stages in the supply chain of the fuel industry. Vulkanox® 4005 is used during the gasoline manufacture process as a short-term stabilizer preventing gum formation due to the oxidation of gasoline components.

In the storage of fuel products Vulkanox® 4005 has proven its effectiveness as an anti-oxidant to increase the oxidation stability of diesel and biodiesel blends as well as for the long-term storage stability of strategic gasoline and diesel supplies. Also in diesel with a significant amount of bio-components Vulkanox® 4005 prevents oxidation of these bio-components otherwise resulting in fouling of fuel tanks and modern engine fuel injection systems.



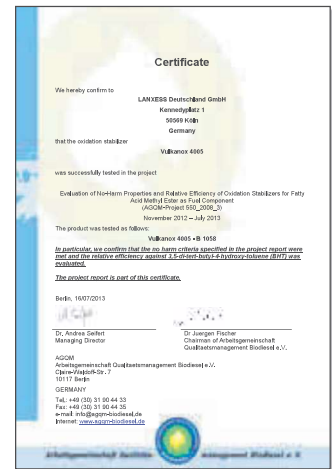
- Performance of Vulkanox® antioxidants in fuels and oils studied in the laboratory

Vulkanox® 4005 obtained the No-Harm Certificate from the German Institute AGQM Biodiesel.

In cooperation with the mineral oil industry the AGQM developed certain test criteria. Additives have to pass for a safe use from blending the mineral diesel with biodiesel and the application and combustion of the diesel containing up to 10% biodiesel in the engine.

Vulkanox® 4005 can be found on the published AGQM list which is named as a reference in the German fuel standard DIN 51628.

LANXESS is leveraging its knowledge and expertise on oxidation chemistry to develop further aminic antioxidants highly effective in group I base oils as well as in the high performance group III base oils. Please get in contact with our technical experts to find out more about these opportunities, LANXESS products can offer.



- AGQM-Certificate

Polymer protection by Vulkanox® products

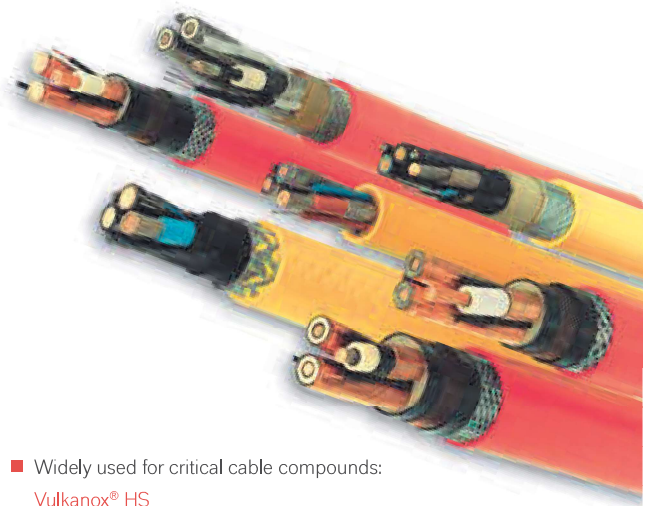
Vulkanox® 4030 is a liquid phenylene diamine antioxidant similar to Vulkanox® 4005, however, with larger carbon groups attached to it affecting its solubility in fuels and oils. Vulkanox® 4030 is slightly more effective in group I base oils. Furthermore, Vulkanox® 4030 can be used to reduce fouling of catalyst in crude cracking and as column antifoulant, as polymer stabilizer in E-SBR production, as polymer inhibitor in monomer processing (e.g. acrylate monomer) and as chain extender in the manufacturing of polyurea for coatings.



■ Manufacturing process of polyurea for coatings

Vulkanox® MB2 is typically used as effective antioxidant and synergist for the primary antioxidant, a hindered phenol. Another application is the use of Vulkanox® ZMB2 in peroxide cured EPDM cable insulation where it increases the electrical resistivity of the insulation shell.

Polymer and material protection with Vulkanox®



■ Widely used for critical cable compounds:
Vulkanox® HS

Vulkanox® HS shows excellent oxidation prevention even in peroxide cured polymers. Besides rubber applications it can be used to protect e.g. cross-linked polyethylene (XPE). With our special salt free quality of Vulkanox® HS, LANXESS Advanced Industrial Intermediates (AII) offers a valuable product to industries, where highest purity standards are needed. In particular this product is widely used in the manufacturing of critical cable compounds.

Vulkanox® ZMB2 is also a very effective non-staining antioxidant for use in white and colored peroxide cured electrical cable insulation applications contributing to an increased electrical resistivity of the polymer insulation material.

DISCLAIMER

Additional information

Information concerning compliance with FDA and BfR regulations as also hazard categories can be obtained on request.

Product safety:

Relevant safety data and references as well as the possibly necessary warning labels are to be found in the corresponding safety data sheets.

Health and Safety Information:

Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling the LANXESS products mentioned in this publication. For materials mentioned which are not LANXESS products, appropriate industrial hygiene and other safety precautions recommended by their manufacturers should be followed. Before working with any of these products, you must read and become familiar with the available information on their hazards, proper use and handling. This cannot be overemphasized. Information is available in several forms, e.g., material safety data sheets and product labels. Consult your LANXESS representative in Germany or contact the Industrial & Environmental Affairs Department (IEA) of LANXESS Germany or - for business in the USA - the LANXESS Product Safety and Regulatory Affairs Department in Pittsburgh, PA.

Regulatory Compliance Information: Some of the end uses of the products described in this publication must comply with applicable regulations, such as the FDA, BfR, NSF, USDA, and CPSC. If you have any questions on the regulatory status of these products, contact your LANXESS Corporation representative, the LANXESS Regulatory Affairs Manager in Pittsburgh, PA or the Industrial & Environmental Affairs Department (IEA) of LANXESS Germany.

Forward-looking statements:

This product information contains forward-looking statements based on current assumptions and forecasts made by the LANXESS AG management. Various known and unknown risks, uncertainties and other factors could lead to material differences between the actual future consolidated results, financial situation, development or performance of the company, and the estimates given here. The company assumes no liability to update such forward-looking statements or to conform them to future events or development.

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