



Your Innovation Compass in Organic Peroxides for Polymer Modification

Nouryon

Nouryon Creates Everyday Essentials

Nouryon is your partner in essential solutions for a sustainable future.

We are a global, specialty chemicals leader. Markets and consumers worldwide rely on our essential solutions to manufacture everyday products, such as personal care, cleaning goods, paints and coatings, agriculture and food, pharmaceuticals, and building products. Furthermore, the dedication of approximately 8,200 employees with a shared commitment to our customers, business growth, safety, sustainability and innovation has resulted in a consistently strong financial performance. We operate in over 80 countries around the world with a portfolio of industry-leading brands.

Within our Polymer Specialties business, we produce everyday essentials for the global polymer, recycling and polymer processing industries. We are among the world's leading producers of organic peroxides, metal alkyls and organo-metallic specialties, which are essential ingredients for the thermoplastic, composite and rubber industries. We are widely known for our world-class products, including Butanox®, Trigonox®, Perkadox® and Ketjenblack® brands.

As a company of innovation, we have recently introduced new initiators, which have an improved performance in selectivity and HSE profile, including Trigonox® 421 and Trigonox® 301 products for example.

A global partner

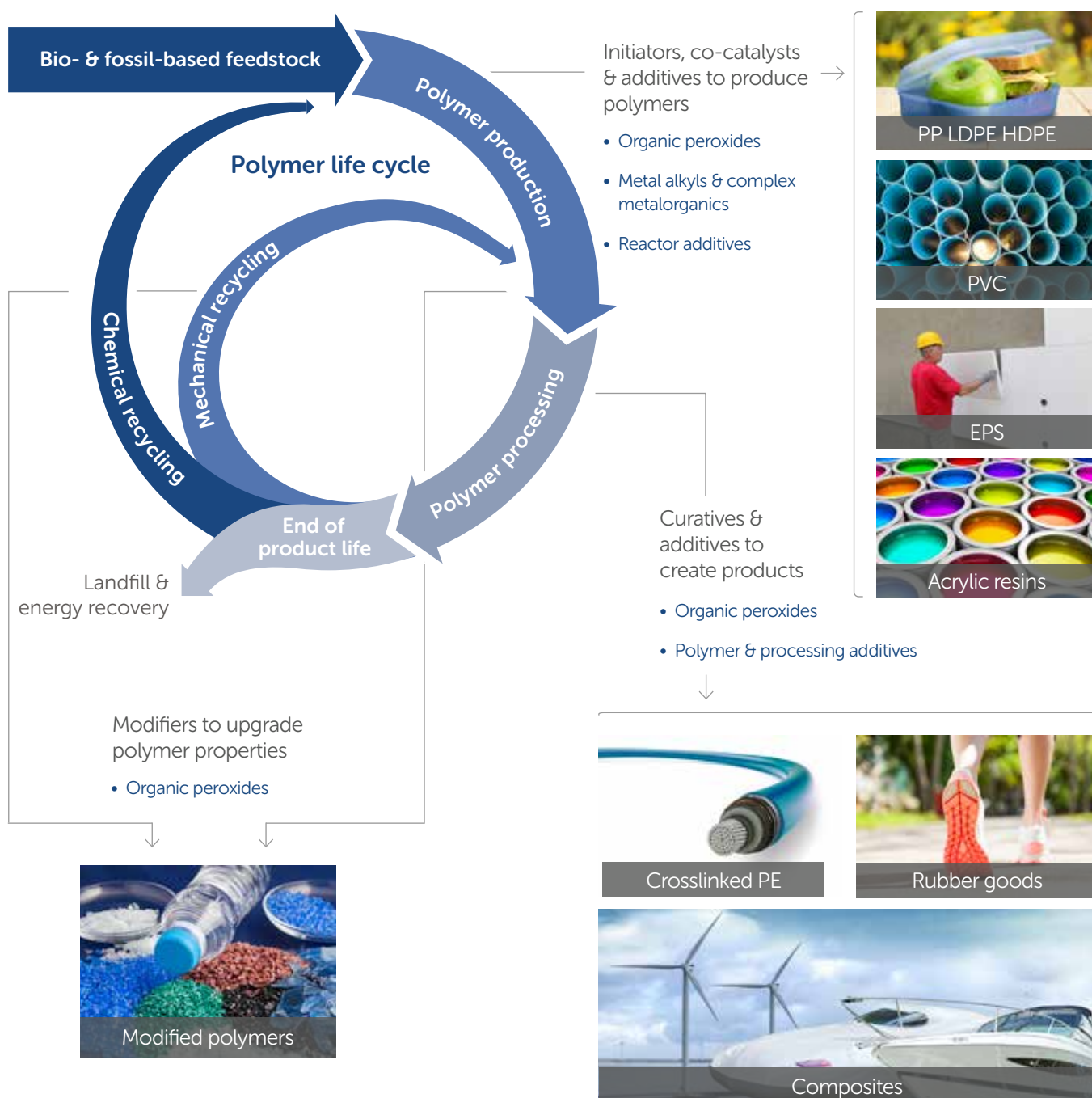
Our manufacturing sites and distribution centers are found all around the globe. Our global distribution network allows us to deliver our products to you anywhere in the world. That's how we ensure security of supply and easy access to quality products wherever you are.

All our sites are ISO 9001 and ISO 14001 certified to ensure the highest product quality and strict compliance with environmental regulations. We continually invest in manufacturing techniques, high quality standards, safety, innovation, active technical support and a reliable supply chain.



Enabling the Polymer Cycle

Building on a sustainability driven strategy. We provide essential ingredients to enable the polymer cycle.



Contributing to a Sustainable Future

We partner with our customers, suppliers and employees to deliver innovative solutions, drive progress and create a safe and sustainable today and tomorrow for everyone.

Our 'Commitment to a Sustainable Future,' is based on three pillars:

IMPROVE	GROW	ENGAGE
<p>Improve our safety and environmental performance</p> <p>Key sustainable development goals:</p> 	<p>Innovate to create Sustainable Solutions, enabling customers to be more sustainable</p> <p>Key sustainable development goals:</p> 	<p>Engage with customers, suppliers, employees, and society to drive progress</p> <p>Key sustainable development goals:</p> 
       		

Our effort to **IMPROVE** our environmental performance includes ambitious targets:

Safety ambition: zero injuries and harm
2030
By the end of 2030, we have targeted reducing our absolute Scope 1 & 2 Greenhouse Gas (GHG) emissions by 40% , vs. a 2019 base year
By the end of 2030, we have targeted reducing our total waste intensity by 10% , and water consumption intensity by 10% , vs. a 2019 base year
2050
By 2050, we aspire to be a net zero organization



Our Innovative Products to Enable Polymer Modification

We are the global leader in the production of organic peroxides for the polymer, rubber and resin industry. Markets worldwide rely on our essential chemistry, our global production footprint and safety expertise to enable the polymer life cycle.

The combination of our strong commitment to sustainability and our unique reactive chemistry is what drives Nouryon to develop essential ingredients for the polymer industry. Organic peroxides are reactive molecules activated by temperature. They decompose during extrusion to generate radicals responsible for the modification of polymers.

Our products Trigonox® and Perkadox® enable the polymer industry to expand the range of applications of polyolefins.

The mechanical properties of polymers can be tuned upon selection of the suitable reactive peroxide. Trigonox® and Perkadox® can be used to either reduce molecular weight and increase Melt Flow Index (MFI) or to increase

molecular weight and decrease MFI resulting in a polymer with enhanced melt strength.

Applications of modified polypropylene range from fibers for hygiene product and disposable medical protective gear, to food packaging and automotive.

Increase MFI and reduce viscosity (CR-PP)
Trigonox® 101
Trigonox® 301
Trigonox® 501-CS40
Decrease MFI and increase melt strength (HMS-PP)
Perkadox® 24L
Perkadox® PM-60ST-GR
Modification of biopolymers (HMS-PLA)
Trigonox® 301
Trigonox® 501-CS40



Controlled Rheology PP (CR-PP)

Reaching target MFI and delivering consistent product quality.

Our products Trigonox® and Perkadox® allow to expand the range of applications of polypropylene (PP).

One important negative aspect of polypropylene is its very high melt elasticity causing processing problems on high-speed equipment. Controlled-rheology polypropylene (CR-PP) is produced reducing the melt elasticity by narrowing the typically broad molecular weight distribution of virgin polypropylene.

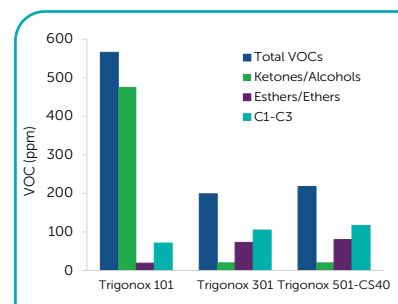
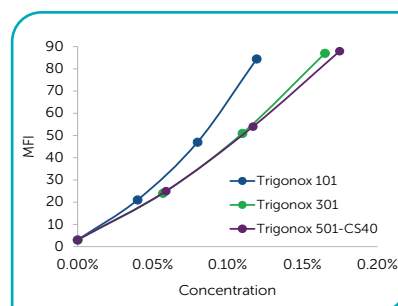
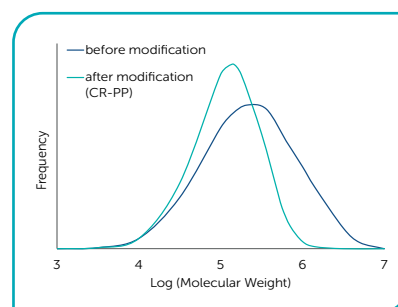
Our products can be used to reduce molecular weight and increase Melt Flow Index (MFI) and to narrow molecular weight distribution, important to enable specific applications (e.g fibers production).

Moreover, organic peroxides are used to rapidly produce additional PP grades post-reaction (during extrusion), resulting in key benefits:

- no need to adjust process conditions/catalyst system during polymerization and
- low amount of off-spec material during catalyst switch

Trigonox® 101, Trigonox® 301 and Trigonox® 501-CS40 are the organic peroxides of choice to control the rheology of polypropylene.

Trigonox® 101 is slightly more effective on an equal weight basis. However, Trigonox® 301 and Trigonox® 501-CS40 generate lower VOCs levels compared to Trigonox® 101. Tertiary Butyl Alcohol (TBA) and acetone as well as aromatics are absent when using Trigonox® 301 and Trigonox® 501-CS40. Trigonox® 301 and Trigonox® 501-CS40 have FDA and BfR food contact approvals. They are suitable for food packaging, hygiene products and automotive interiors.



Improvements	1 st generation Trigonox 101	2 nd generation Trigonox 301	3 rd generation Trigonox 501-CS40
Residual VOCs	●	●	●
Odor & smell of PP	●	●	●
FDA approval	●	●	●
Transport classification	●	●	●
Storage requirements	●	●	●



High Melt Strength PP (HMS-PP)

Introducing long chain branching and improving mechanical properties.

Polypropylene (PP) is a linear polymer with low melt strength, limited strain hardening and poor processing at high strain rates.

High Melt Strength

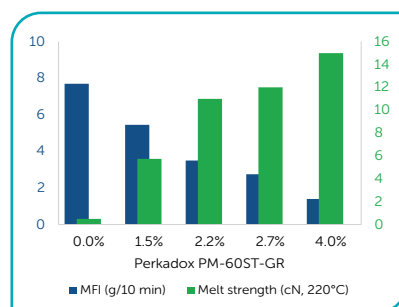
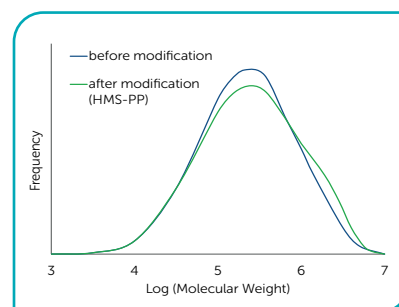
Polypropylene is therefore more suitable for applications where high-melt-strength (HMS) is required, like foaming (narrow processing window, non-uniform cell size), blow molding (lack of strain hardening), thermoforming (sheet sagging, thinning, pin-holes) and extrusion coating (melt resonance, high neck-in).

Our peroxides, Perkadox® 24L and Perkadox® PM-60ST-GR are used to increase molecular weight and decrease MFI resulting in a polymer with enhanced melt strength or HMS-PP.

The Introduction of long chain branches improves the mechanical properties of PP, such as impact, flexural and tensile strength.

Perkadox® 24L is an effective peroxide for improving melt strength of polypropylene. It is very reactive; the modification reaction starts at relatively low temperature. It is therefore advised to only use it with polypropylene (reactor) powder. Perkadox® 24L is FDA approved for PP food contact applications.

Perkadox® PM-60ST-GR is suitable for modification of PP pellets. This is because Perkadox® PM-60ST-GR has a relatively high thermal stability allowing PP to melt in the extruder before the reaction starts. Perkadox® PM-60ST-GR is not approved for food contact applications.



	Perkadox 24L	Perkadox PM
PP type	powder (reactor grade)	pellets, flakes
Dose (%)	0.5 - 2.0	0.5 - 2.0
Conditions extrusions	nitrogen	nitrogen or air
Food contact	FDA approval	not approved

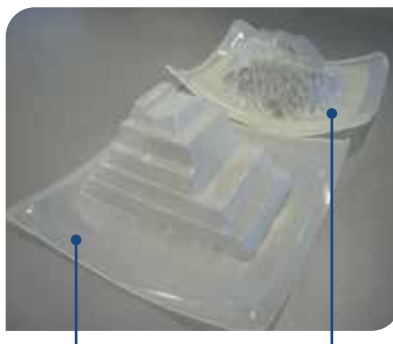
Foaming



Commercial HMS-PP

HMS-PP after modification with Perkadox® 24

Thermoforming



HMS-PP after modification with Perkadox® 24

Blank PP

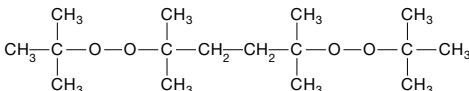
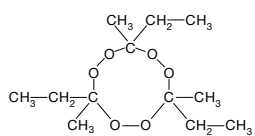
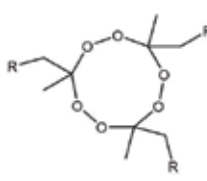
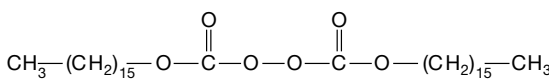
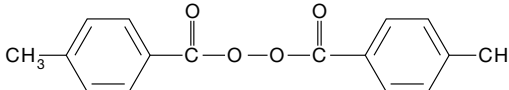
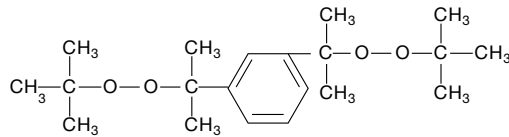
Blow molding



HDPE drum

HMS-PP after modification with Perkadox® 24

Our Products

PRODUCT NAME	CHEMICAL NAME [CAS NUMBER]	GENERAL DATA		
		Molecular weight	Assay (%)	Active oxygen (%)
	2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane [78-63-7]	290.4		11.02
TRIGONOX 101			92	10.14
TRIGONOX 101-20PP			20	2.20
TRIGONOX 101-E70			70	7.71
	3,6,9-Triethyl-3,6,9-trimethyl-1,4,7-triperoxonane [24748-23-0]	264.3		18.16
TRIGONOX 301			41	7.45
TRIGONOX 301-20PP			8	1.45
	1,2,4,5,7,8-Hexoxonane, 3,6,9-trimethyl-3,6,9-tris (Et and Pr) [1613243-54-1]			17.8
TRIGONOX 501-CS40	 <p>R = Methyl or Ethyl</p>		40	7.14
TRIGONOX 501-CS30			30	5.33
	Dicetyl peroxydicarbonate [26322-14-5]	570.9		2.80
PERKADOX 24L			91	2.55
PERKADOX 24-FL			94.5	2.65
	Di(4-methylbenzoyl) peroxide [895-85-2]	270.3		5.91
PERKADOX PM-60ST-GR			60	3.35
	Di(tert-butylperoxyisopropyl) benzene [25155-25-3; 2212-81-9]	338.5		9.45
PERKADOX 14S-FL			96	9.08
PERKADOX 14-40B-PD			40	3.8
PERKADOX 14-EP40			40	3.8

* for land and sea transport and classified as Organic peroxide type C; UN 3103 for air transport

** classified as flammable solid; class 4.1; UN 1325

Physical form	STORAGE DATA		KINETIC DATA T (°C) FOR T1/2					SAFETY DATA					STANDARD PACKAGE TYPE
	T _s max. (°C)	T _s min. (°C)	0.1 h	10 h	10 h	A (1/s)	E _a (kJ/mole)	SADT (°C)	T _{em} (°C)	T _c (°C)	UN No.	Hazard class.	
			156	134	115	1.68E+16	155.49						
liquid	40	10						80			3103	C	HDPE can / HDPE drum
on polypropylene, beads	30							70			3108	G	carton
solution in mineral oil	40	5						75			3109	F	HDPE can/IBC
			170	146	125	1.02E+15	150.23						
solution in iso-paraffins	40	10						110			3105	D	HDPE can
on polypropylene, beads	40							90			3110	F	carton
			170	146	125	1.09E+15	150.60						
liquid	40	-25						110			3105	D	HDPE can
liquid	40	-30						110			3109*	F	HDPE can
			84	65	48	3.02E+15	124.30						
powder	20							40	35	30	3120	F	carton
flakes	20							40	35	30	3120	F	carton
			110	88	70	5.11E+15	134.4						
granules	30							80	30	5	3110	F	carton
			156	134	114	7.65E+15	152.69						
flakes	20							80			3106	D	carton
powder	30							80			1325	**	carton
granules	30							80			1325	**	carton

Modification of Biopolymers



Increasing melt strength by introducing long chain branching.

Poly(lactic acid) (PLA) is a biodegradable and renewable thermoplastic polyester. PLA has some limitations that impact its processing window and therefore its application range:

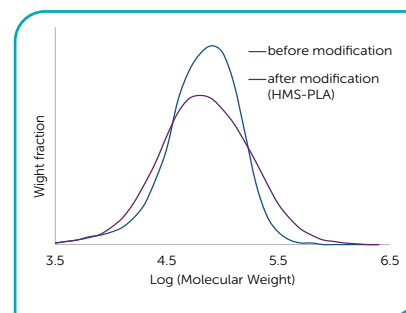
- Linearity of the polymer chain, leading to low melt elasticity and impact strength
- Crystallinity, giving a relatively low heat distortion temperature

The molecular weight distribution of PLA can be broadened by modification

with organic peroxides like Trigonox® 101, Trigonox® 301 and Trigonox® 501-CS40, which all can lead to the formation of a high molecular weight tail. The PLA modified with Trigonox® 301 (and Trigonox® 501-CS40) is completely soluble (no gel formation observed).

Our peroxides can induce long chain branching of other biopolymers (next to PLA), such as poly-3-hydroxyvalerate (PHV) and poly-4-hydroxybutyrate (P4HB) among others.

With the introduction of long chain branching and improved melt strength PLA and other biopolymers can be successfully used in applications such as film blowing, extrusion coating and foaming.



Other Applications

Modification of polyethylene

Recently LDPE production process has been shifting towards tubular reactors for their lower operational costs. Tubular LDPE is less suitable for applications such as extrusion coating due to its narrow molecular weight distribution and low degree of long chain branching. Post reactor reactive extrusion with organic peroxides such as Trigonox® 301 or Trigonox® 501-CS40 is used to introduce long chain branching, hence increasing the melt strength and making tubular LDPE suitable for extrusion coatings applications.

Grafting Maleic Anhydride on polyolefins

Modification of olefinic polymers (i.e. PE and PP) with maleic anhydride is generally needed to promote the adhesion to metals, mineral fillers, glass fibers or to other polymers such as nylon. The modification is mostly carried out in a solution or in the polymer melt by a radical grafting reaction using an organic peroxide. Perkadox® 14 and Trigonox® 101 can be used to graft maleic anhydride to LDPE, EPDM and PP.

Recycling of polyolefins

Organic peroxides such as Trigonox® 501-CS40 and Perkadox® PM-60ST-GR are used in advanced mechanical recycling of polyolefins to improve the mechanical properties and the performance of recycle. They enable the recycling industry to meet increasingly demanding market needs in terms of quality and recycled content, to produce more recycled grades from available feedstocks and to expand the range of application of recycled polyolefins. They allow 100% recycled content claims and enable re-recyclability. Check out our polymer recycling brochure for more information.

Your Safety Our Priority



Nouryon is recognized as the global leader in organic peroxide safety. Our proven success in safely handling organic peroxides is due to our long-term commitment to developing and maintaining high safety standards. We at Nouryon always place safety as our top priority.

Sharing our experience in safety is one of the most important resources we offer. Through our safety programs we provide expert advice on the handling of our products including:

- classroom review of safety and handling of organic peroxides
- consultation on storage and dosing facility design
- demonstrations on the safe use, handling and control of organic peroxides

Our Safety Research Laboratory in Deventer, The Netherlands is heavily involved in R&D, ensuring the development of safe products and processes. Studies are carried out, in order to provide a high level of safety in manufacturing, handling and transport of dangerous goods.

In general organic peroxides are thermally unstable compounds, decomposing at relatively low temperatures. However, knowledge of proper handling techniques, carefully designed facilities and thorough training of personnel can overcome the hazards. Personnel who understand and pay proper attention will be able to handle organic peroxides confidently and safely.



Scan QR code to watch our short video on our safety services

Storage temperatures

SADT: Self-Accelerating Decomposition Temperature

The SADT is the lowest temperature at which self-accelerating decomposition may occur with a substance in the packaging as used in transport. Transportation temperatures are derived from the SADT according to the recommendations by the United Nations Committee of Experts on the Transport of Dangerous Goods.

$T_s \text{ max.}$

The $T_s \text{ max.}$ given in the product list on pages 8-9 is the recommended maximum storage temperature at which the product is stable and quality loss will be minimal.

$T_s \text{ min.}$

A minimum storage temperature ($T_s \text{ min.}$) is given if phase separation, crystallization or solidification of the product is known to occur below the temperature indicated. We recommend that you store the product above the $T_s \text{ min.}$ indicated for quality and in some cases safety reasons.

T_{em} : Emergency temperature

The T_{em} is derived from the SADT and is the temperature at which emergency procedures must be implemented.

T_c Control temperature

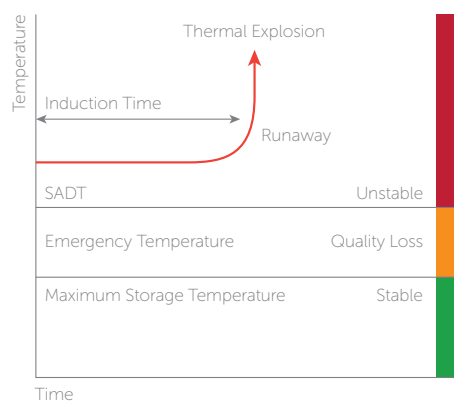
The T_c is also derived from the SADT and is the maximum temperature at which the product can be safely transported. A T_c is not required if the SADT exceeds 50°C.

Both the T_{em} and T_c are related to safety and do not apply to product quality. To maintain product quality the recommended storage temperatures ($T_s \text{ min.}$ and $T_s \text{ max.}$) have to be observed.

UN Numbers

All products accepted for transport are assigned to generic entry numbers according to classification principles as described in the recommendations by the United Nations Committee of Experts on the Transport of Dangerous Goods.

Survey of thermal stability



Contact Us

For product inquiry and ordering information, please contact your Nouryon account manager or regional Nouryon sales office.

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Additional information

Product Data Sheets (PDS) and Safety Data Sheets (SDS) for our polymerization initiators are available at nouryon.com

All information concerning this product and/or suggestions for handling and use contained herein are offered in good faith and are believed to be reliable. Nouryon, however, makes no warranty as to accuracy and/or sufficiency of such information and/or suggestions, as to the product's merchantability or fitness for any particular purpose, or that any suggested use will not infringe any patent. Nouryon does not accept any liability whatsoever arising out of the use of or reliance on this information, or out of the use or the performance of the product. Nothing contained herein shall be construed as granting or extending any license under any patent. Customer must determine for himself, by preliminary tests or otherwise, the suitability of this product for his purposes. The information contained herein supersedes all previously issued information on the subject matter covered. The customer may forward, distribute, and/or photocopy this document only if unaltered and complete, including all of its headers and footers, and should refrain from any unauthorized use. Don't copy this document to a website.

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