

LUPEROX[®]
BY ARKEMA

ORGANIC PEROXIDES /

Polymer crosslinking

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A global chemical company and France's leading chemicals producer, **Arkema** is building the future of the chemical industry every day. Deploying a responsible, innovation-based approach, we produce state-of-the-art specialty chemicals that provide customers with practical solutions to such challenges as climate change, access to drinking water, the future of energy, fossil fuel preservation and the need for lighter materials. With operations in more than 40 countries, some 14,000 employees and 10 research centers, Arkema generates annual revenue of approximately 6.4 billion, and holds leadership positions in all its markets with a portfolio of internationally recognized brands.

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See MSDS for Health & Safety Considerations.

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ARKEMA, INNOVATIVE CHEMISTRY

The Arkema group is one of the main global producers of organic peroxides. Its expertise also extends to glass coatings, additives for PVC, catalysts for synthesis in fine chemicals, polyester resins and specialty epoxides.

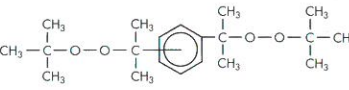
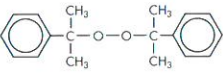
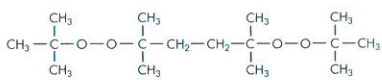
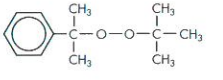
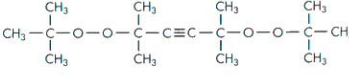
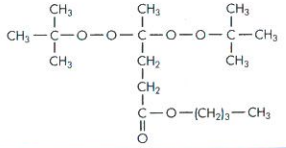
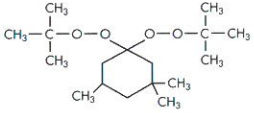
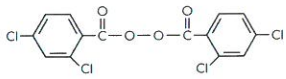
The Organic peroxides activity, headquartered in King of Prussia (United States), operates facilities throughout the world. Its products, services and technical support are available to customers in Europe, North America, Asia, Africa and the Middle East.

Arkema is building the future of the chemical industry using a responsible, innovation-based approach.

France's leading chemicals producer, Arkema is aiming to become one of the global leaders in specialty chemicals. With its 14,000 employees and 91 industrial sites in 40 countries, Arkema has a revenue of 6.4 billion. The Arkema group was created in October 2004, following the reorganization of Total's Chemicals branch. Thanks to innovation, targeted acquisitions and investments in emerging countries, it has become a recognized world player in the field of specialty chemicals.

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FAMILY NAME	CHEMICAL NAME	CHEMICAL FORMULA	PRODUCT NAME	PHYSICAL FORM	ASSAY (%)	ACTIVE OXYGEN	Half-life temperature (°C) in Benzene			CARRIER	UN	SADT	STORAGE TEMPERATURE		PACKAGING						
							10h	1h	1min				Ts max	Ts min							
LUPEROX® F	1,3-1,4-bis(tert-butylperoxy)isopropyl benzene Cas N° 25155-25-3 Molecular weight: 338.5 g Melting point: 37-54°C Active oxygen: 9.45%		LUPEROX® F Flakes	solid flakes	96 min	9.1%	121	142	185	-	3106	70°C	30°C	-	20 kg bag in carton box						
			LUPEROX® FreeO	solid flakes	96 min	9.1%				-	3106	70°C	30°C	-	20 kg bag in carton box						
			LUPEROX® MIX	paste	37	3.5%				-	3077	90°C	40°C	-	25 kg in plastic bin						
			LUPEROX® F90P	powder	90	8.5%				Silica	3106	80°C	30°C	-	20 kg bag in carton box						
			LUPEROX® FreeO-40 LUPEROX® F40P LUPEROX® F40 LUPEROX® F40P-SP2	granule powder granule powder	40	3.8%				Calcium carbonate + Silica	Ask Arkema 3106	80°C	30°C	-	20 kg bag in carton box						
			LUPEROX® F40KEP LUPEROX® F40KE	powder granule	40	3.8%				Kaolin	Ask Arkema	80°C	30°C	-	20 kg bag in carton box						
			LUPEROX® F40MG LUPEROX® F40MF LUPEROX® F40MG-SP	pellet sheet pellet	40	3.8%				EPM	Ask Arkema	80°C	30°C	-	25 kg bag in carton box 20 kg bags in big box						
			LUPEROX® F40MGVET LUPEROX® F40MFEVT	pellet sheet	40	3.8%				EPM + EVA + Silica	Ask Arkema	80°C	30°C	-	25 kg bag in carton box 20 kg bags in big box						
			LUPEROX® F40ED LUPEROX® F40EDF	pellet sheet	40	3.8%				EPM + Calcium carbonate + Silica	Ask Arkema	80°C	30°C	-	25 kg bag in carton box 20 kg bags in big box						
			LUPEROX® F40M-SP	pellet																	
			LUPEROX® DCP	Dicumyl peroxide Cas N° 80-43-3 Molecular weight: 270.4 g Melting point: > 39°C Active oxygen: 5.92%		LUPEROX® DCP				solid crystals	99 min	5.9%	117	137	178	-	3110	90°C	30°C	-	20 kg bag in carton box
						LUPEROX® DC40P LUPEROX® DC40 LUPEROX® DC40P-SP2				powder granule powder	40	2.4%				Calcium carbonate + Silica	3077	80°C	30°C	-	20 kg bag in carton box
						LUPEROX® DC40KEP LUPEROX® DC40KE				powder granule	40	2.4%				Kaolin	3077	80°C	30°C	-	20 kg bag in carton box
LUPEROX® DC40MG LUPEROX® DC40MF LUPEROX® DC40MG-SP2	pellet sheet pellet	40				2.4%	EPM	3077	80°C	30°C	-	25 kg bag in carton box 20 kg bags in big box									
LUPEROX® DC40MGF LUPEROX® DC40M-SP2	pellet pellet	40				2.4%	EPM + Calcium carbonate + Silica	3077	80°C	30°C	-	25 kg bag in carton box 20 kg bags in big box									
LUPEROX® DC40MGPE	pellet	40				2.4%	EPM + LPDE	3077	80°C	30°C	-	25 kg bag in carton box 20 kg bags in big box									
LUPEROX® DC40PE	powder	40				2.4%	LPDE	3077	80°C	30°C	-	25 kg bag in carton box									
LUPEROX® 101	2,5-dimethyl-2,5-di(tert-butylperoxy) hexane Cas N° 78-63-7 Molecular weight: 290.4 g Melting point: 8°C Active oxygen: 11.01%					LUPEROX® 101	liquid	94 min	10.4%	120	140	181				-	3103	82°C	30°C	8°C	25 kg in plastic bin
						LUPEROX® 101XLS50	powder	50	5.5%							Silica	3108	75°C	30°C	-	20 kg bag in carton box
						LUPEROX® 101XL45 LUPEROX® 101XL45-SP2	powder	45	5.0%							Calcium carbonate + Silica	3108	75°C	30°C	-	20 kg bag in carton box
LUPEROX® 801	Tert-butylcumylperoxide Cas N° 3457-61-2 Molecular weight: 208.3 g Melting point: 11.3-19.5°C Active oxygen: 7.7%		LUPEROX® 801	liquid	95 min	7.4%	124	144	185	-	3107	84°C	30°C	16°C	25 kg in plastic bin						
LUPEROX® 130	2,5-dimethyl-2,5-di(tert-butylperoxy) hex-3-yne Cas N° 1068-27-5 Molecular weight: 286.42 g Active oxygen: 11.2% Note: this product only exists as extended grade		LUPEROX® 130MO85	liquid	85	9.5%	131	152	194	White oil	3103	90°C	30°C	8°C	25 kg in plastic bin						
			LUPEROX® 130XL45	powder	45	5.0%				Calcium carbonate + Silica	3106	90°C	30°C	-	20 kg bag in carton box						
LUPEROX® 230	n-butyl-4,4-di(tert-butylperoxy)valerate Cas N° 995-33-5 Molecular weight: 334.4 g Active oxygen: 9.57% Note: this product only exists as extended grade		LUPEROX® 230G40	granule	40	3.8%	109	129	170	Calcium carbonate + Sodium aluminium silicate	3108	60°C	30°C	-	20 kg bag in carton box						
			LUPEROX® 230XL40 LUPEROX® 230XL40-SP	powder powder	40	3.8%				Calcium carbonate + Silica	3108	60°C	30°C	-	20 kg bag in carton box						
LUPEROX® 231	1,1-di(tert-butylperoxy)-3,3,5-trimethylcyclohexane Cas N° 6731-36-8 Molecular weight: 302.4 g Active oxygen: 10.58% Note: this product only exists as extended grade		LUPEROX® 231G40 LUPEROX® 231XL40	granule powder	40	4.2%	96	115	153	Calcium carbonate + Sodium aluminium silicate	3110	57°C	30°C	-	20 kg bag in carton box						
			LUPEROX® 231XL40-SP	powder	40	4.2%				Calcium Vcarbonate + Silica	3110	57°C	30°C	-	20 kg bag in carton box						
LUPEROX® DCBP	Di(2,4-dichlorobenzoyl) peroxide Cas N° 133-14-2 Molecular weight: 380.0 g Active oxygen: 4.21%		LUPEROX® DCBP	paste	50	2.1%	-	-	-	Silicone oil	3106	60°C	35°C	-	25 kg in plastic bin						

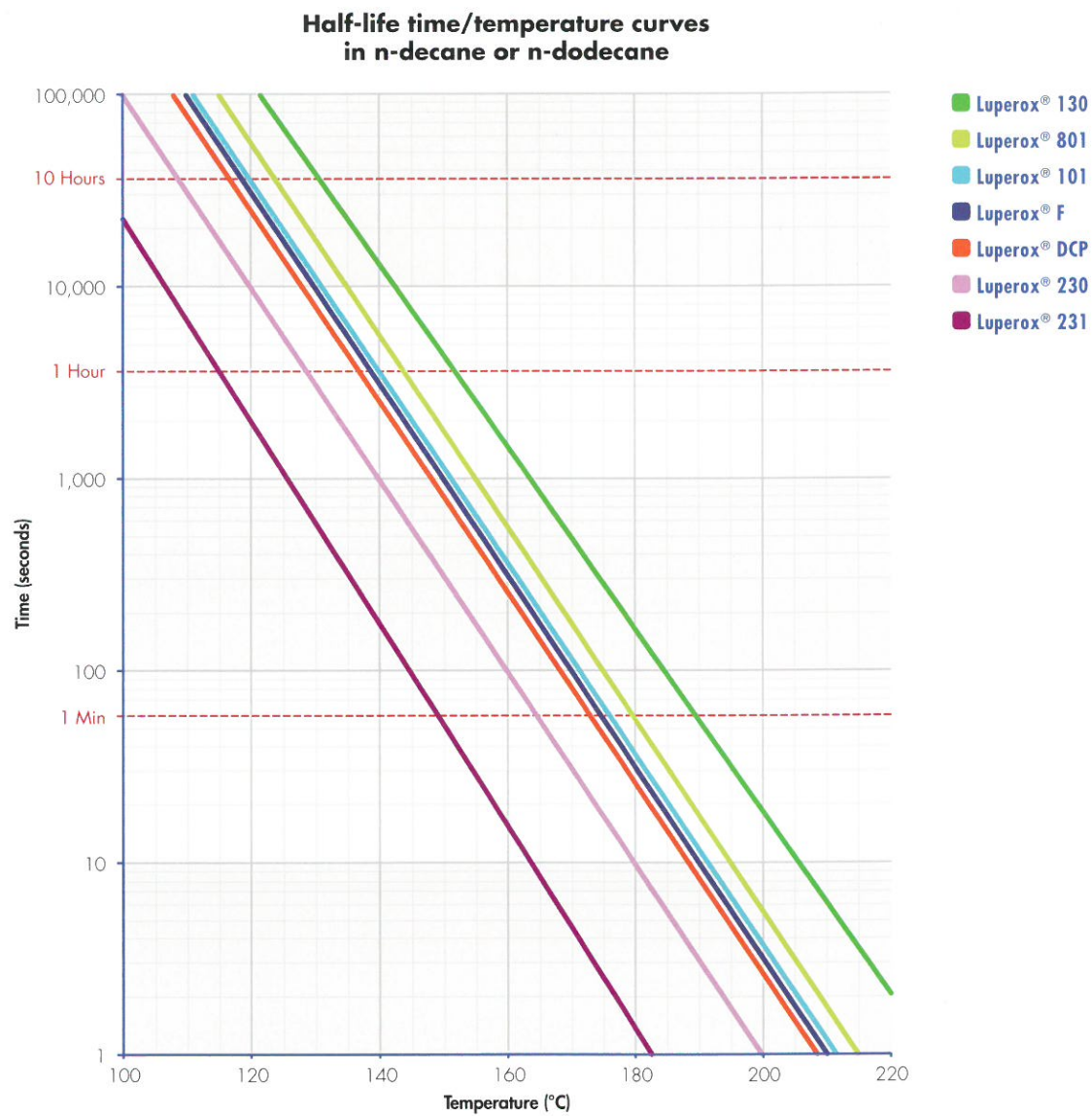
KINETIC AND HALF-LIFE TIME

The half-life of a peroxide at any specified temperature is the time required at that temperature to affect a loss of one half of the peroxide's active oxygen content.

Half-life data is essential for selecting the optimum peroxide for a specific time-temperature combination.

Peroxide half-life data is generated by studying their thermal decomposition in various solvents at low concentrations.

The polarity of the solvent used will influence the peroxide decomposition kinetics. Thus it is important to compare peroxide half-life data generated in the same solvent and at the same concentration.



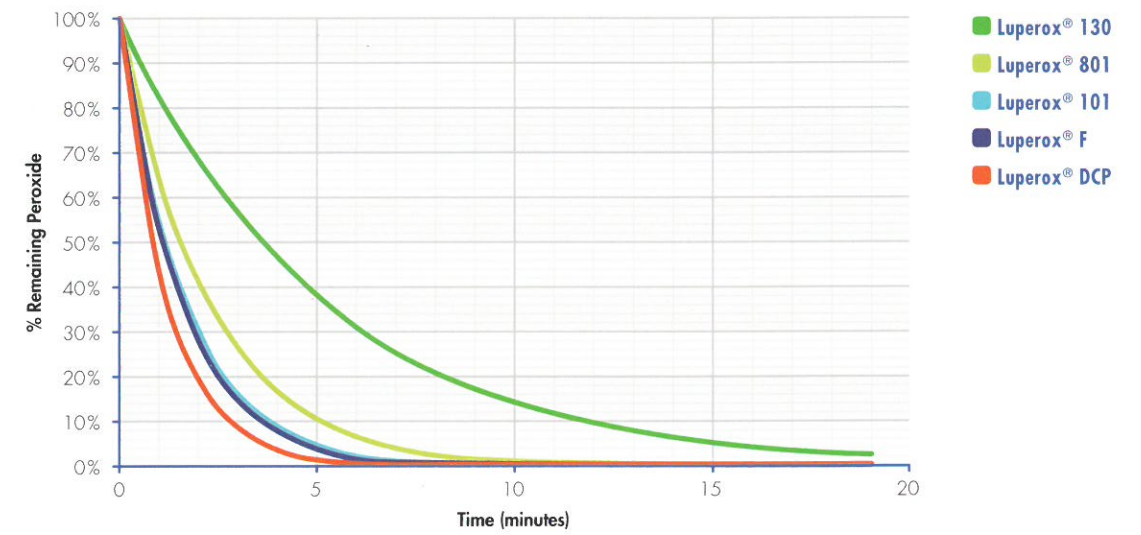
DECOMPOSITION RATE

It is possible to estimate the quantity of reacted organic peroxide as a function of time.

In the following graphs various peroxides are compared for an easy selection based on decomposition rate at given temperatures.

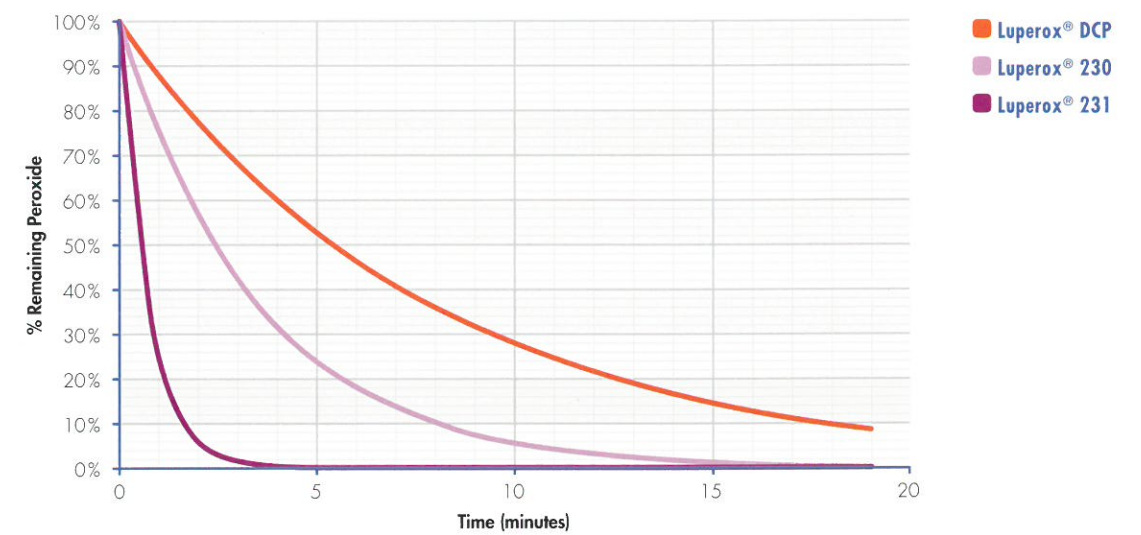
HIGH TEMPERATURE CURING ORGANIC PEROXIDES

% Remaining peroxide vs. time at 180°C



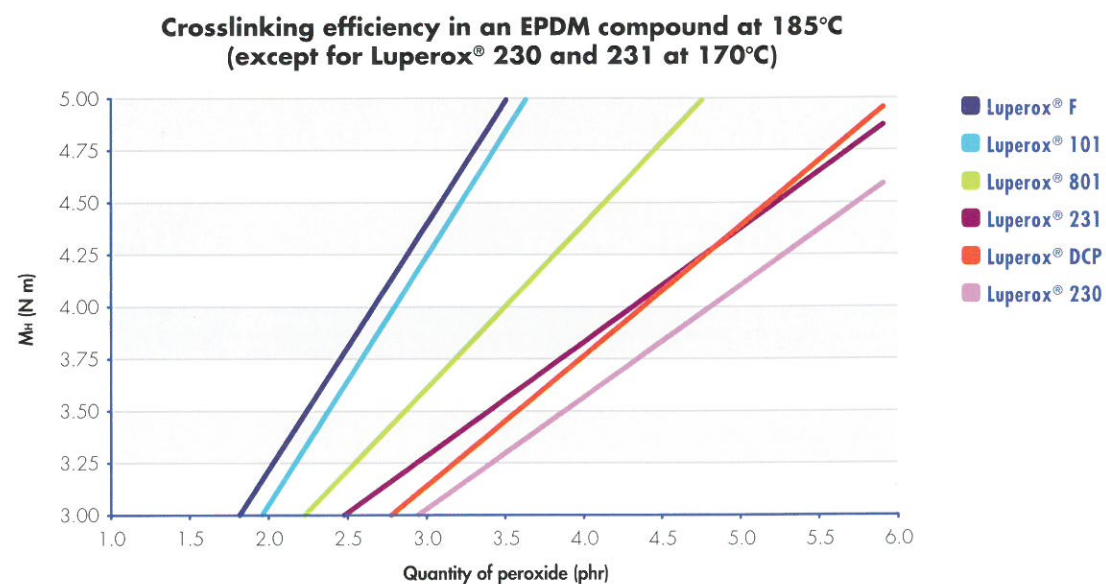
LOW TEMPERATURE CURING ORGANIC PEROXIDES

% Remaining peroxide vs. time at 160°C



CROSSLINKING DENSITY

These data were generated using an ODR2000E rheometer. MH (Nm) is a torque measurement which is proportional to the relative amount of crosslinking bonds created by the peroxide. It is an indication of the mechanical properties to be expected.



SUGGESTED DOSAGE RATE OF LUPEROX® ORGANIC PEROXIDES IN SOME POLYMERS

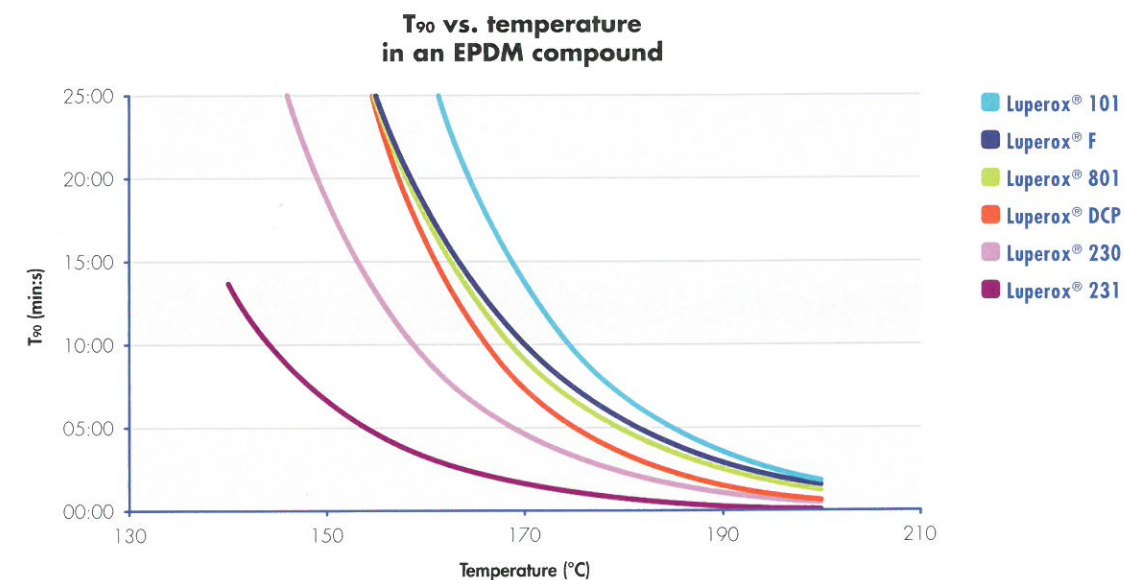
PHR OF ACTIVE SUBSTANCE	LUPEROX® F	LUPEROX® DCP	LUPEROX® 101	LUPEROX® 130	LUPEROX® 801	LUPEROX® 230	LUPEROX® 231	LUPEROX® DCBP
LDPE Low Density Polyethylene	1.2 - 1.8	1.5 - 2.5	1.4 - 2.0		1.2 - 2.0			
HDPE High Density Polyethylene	LUPEROX® MIX 0.8 - 1.6		0.5 - 1.2	0.5 - 1.2				
EVA Ethyl-Vinyl Acetate	0.8 - 1.6	1.2 - 2.0	1.2 - 2.0		1.0 - 1.6	1.4 - 2.6	1.2 - 2.3	
EPM/EPDM Ethylene-Propylene Monomers	1.6 - 3.2	2.4 - 5.4	1.7 - 3.4			3.2 - 6.3	2.4 - 6.0	
CM Chlorinated polyethylene	1.5 - 2.4	2.4 - 3.8	2.5 - 4.0			3.3 - 6.0	3.0 - 5.5	
Q Silicone rubbers	0.2 - 1.0	0.5 - 2.0	0.4 - 1.5					1.4 - 2.0
NBR Butadiene acrylonitrile rubber	0.5 - 1.5	0.9 - 1.7	1.1 - 2.0			1.2 - 2.2	1.0 - 2.0	
SBR Styrene Butadiene Rubber	0.4 - 1.0	0.7 - 1.5	0.7 - 1.2			0.8 - 1.8	0.7 - 1.6	

Example: Typically, 1.6 to 3.2 phr of Luperox® F are used in an EPM/EPDM compound. For formulated peroxide, this quantity has to be divided by the peroxide content. Therefore, 4 to 8 phr of Luperox® F40 is the typical range of quantities used for an EPM/EPDM compound. **SP grades are used at same dosage rate as standard peroxides.**

CURE TIME

These data were generated using an ODR2000E rheometer.

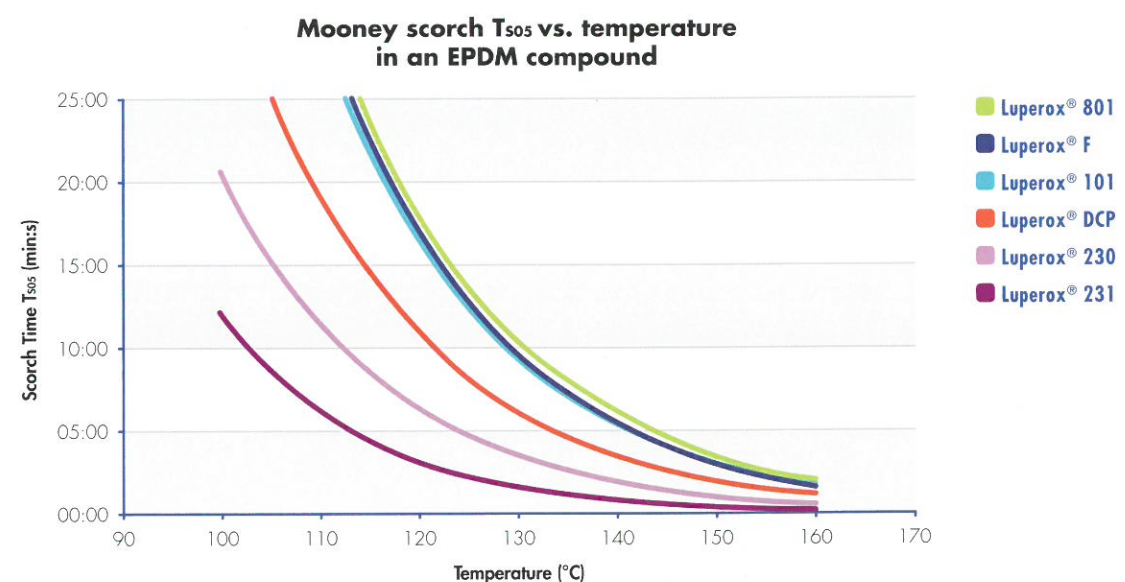
This graph shows the cure time represented by T_{90} , which is the time needed at a specific temperature to get 90% of the peroxide decomposed. This key feature of the peroxide is to be taken into account when selecting the proper peroxide.



SCORCH TIME

The below data were generated using a Mooney viscometer. T_{505} is the scorch time at the processing temperature (usually at the polymer extrusion temperature).

This value represents the time during which the vulcanizable compound can be safely processed before unwanted crosslinking or "scorch" takes place. T_{505} is defined by the time needed at a specific temperature to obtain a 5 Mooney Unit increase in the viscosity as measured from the MV or minimum viscosity.



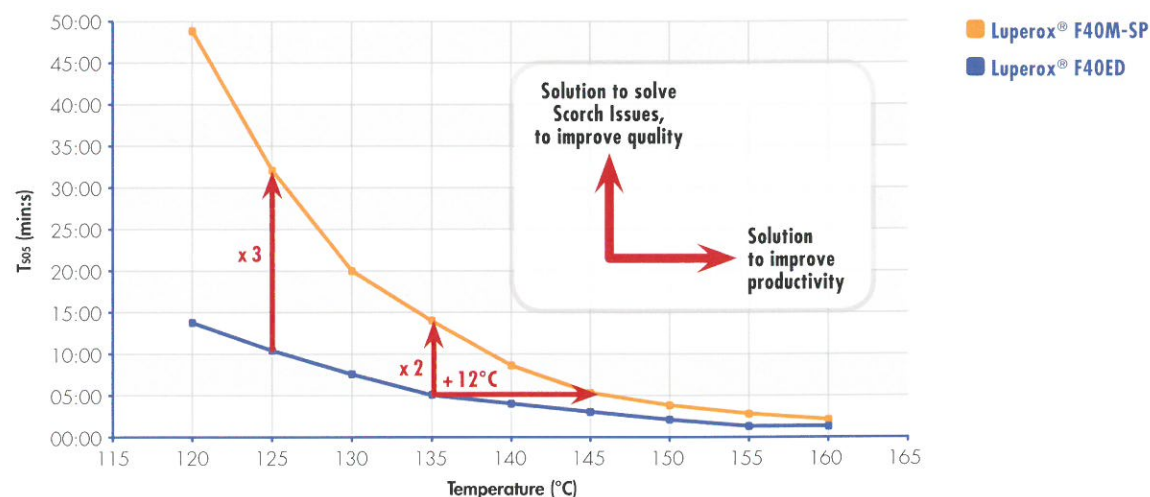
SCORCH PROTECTION TECHNOLOGY

Arkema Scorch Protection technology is a unique technology that provides outstanding protection against scorch both at mixing and crosslinking temperatures.

By increasing the scorch time during mixing and extrusion of the rubber compound, "SP" peroxides are the right technology which allows:

- better process control;
- higher product quality;
- higher productivity.

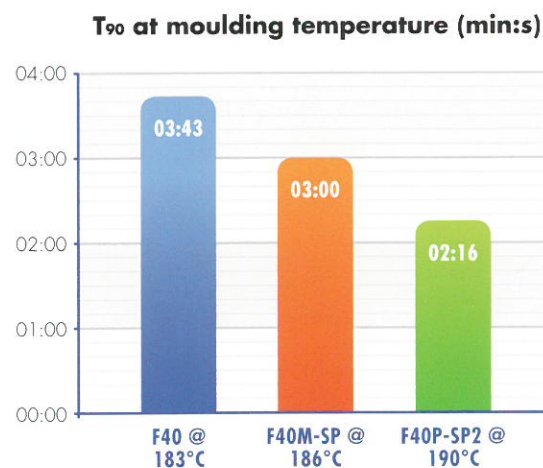
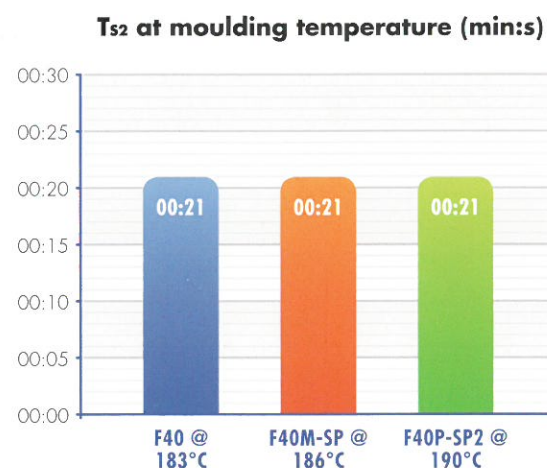
The "SP2" peroxide is the ultimate generation of scorch protection, designed for very scorchy elastomers such as HNBR and very challenging curing conditions such as high injection molding temperature. The Arkema Scorch protection system is an Arkema's patent.



PRODUCTIVITY INCREASE BENEFIT

As it allows to work at higher process temperature without generating scorch, the Arkema Scorch Protection technology allows the increase of process speed leading to the increase of productivity in all applications, including extrusion and moulding.

8 PHR PEROXIDE IN EPDM COMPOUND



LUPEROX® FREEO: SAFER AND ODOURLESS SOLUTION FOR FOAMED EVA

Luperox® FreeO offers to footwear manufacturers an alternative to current technologies commonly used. Sport shoes with soles made of expanded EVA are known for releasing a strong and persistent odour in manufacturing plants, as well as in retail outlets. This smell is due to the crosslinking agent and its VOCs (Volatile Organic Compounds), in particular acetophenone.

Luperox® FreeO offers:

- small amounts of VOC released;
- no release of unpleasant odor;
- outstanding crosslinking efficiency (up to 40% lower dosage);
- easy use thanks to its flakes form.

Luperox® FreeO is a bis isopropyl benzene peroxide.

SMELL FREE

Under typical working conditions organic peroxide decomposes in different molecules.

- Dicumyl peroxide decomposes in acetophenone (52% of total amount), cumyl alcohol and methane. Acetophenone is characterised by a strong and persistent smell.
- Luperox® FreeO decomposes in molecules different in composition and properties. These decomposition products are considered neither smelling nor persistent volatiles. Luperox® FreeO does not contain additives added to mask the odour.

EXCELLENT COST/ PERFORMANCE FEATURES

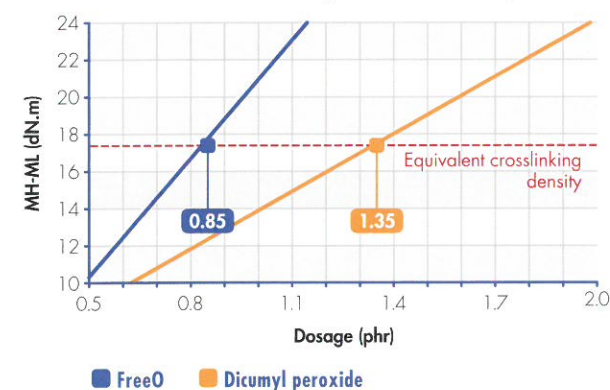
Thanks to its characteristics, Luperox® FreeO is an excellent crosslinking agent for a large range of rubbers allowing reduction of peroxide consumption up to 37%.

Luperox® FreeO is available as pure in flakes form and it allows easy handling and easy weighing.

Luperox® FreeO-40 is the diluted version on calcium carbonate in granule form.

HIGHER CROSSLINKING EFFICIENCY

XL density of EVA foamed compound as function of peroxide dosage



Crosslinking density test demonstrate that Luperox® FreeO does provide the same crosslinking density at 37% lower loading, or higher crosslinking density at the same loading rate.

LOWER VOC GENERATION

Luperox® FreeO does generate 68% lower VOC than DCP.

Luperox® FreeO decomposition products are methane, acetone and ter-butanol, characterised by low boiling point.

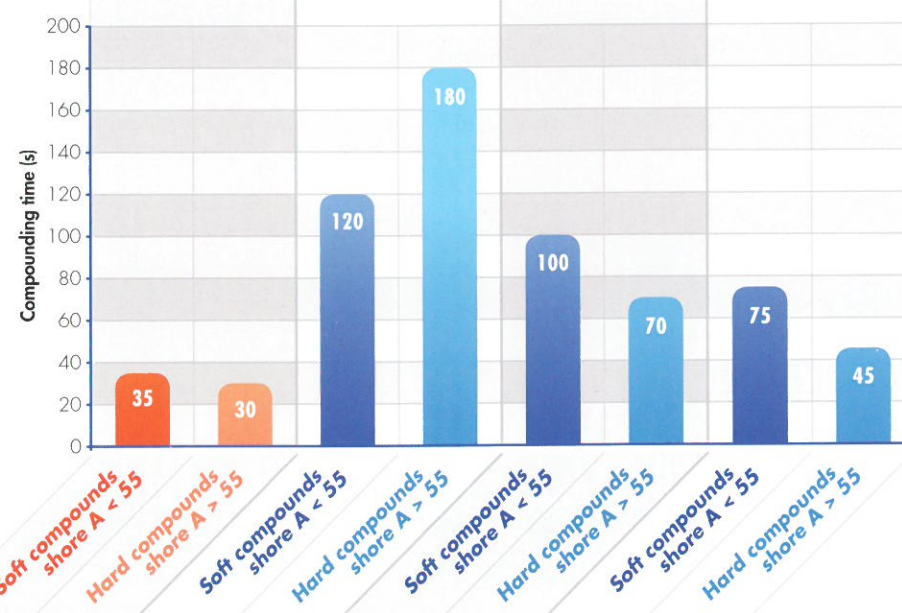
Thanks to its higher efficiency and its composition, Luperox® FreeO generates much lower organic volatiles than other peroxides.

	unit	DCP	Luperox® FreeO
Compound EVA	PHR	115	115
Peroxide	PHR	1.35	0.85
Peroxide	ppm	11760	7404
VOC*: acetophenone, cumyl alcohol, methane	ppm	11760	
VOC*: methane, acetone, t-butanol	ppm		3766

*VOC definition accordingly to D.2004/42/EC

SELECTION / SUGGESTED MIXING TECHNOLOGY

	MASTERBATCHES	LIQUID GRADES	GRANULES	POWDERS
Soaking of polymer pellets		■		
Internal mixer	■		■	■
Open mill	■		■	
Direct peroxide injection		■		
Direct screw compounding without injection	■			



SELECTION / WHY TO USE MASTERBATCH

Experiments were performed with an EPDM compound in a Brabender type internal mixer. Standard deviation of MH was determined using an ODR2000E rheometer after different times of compounding. The times reported in this graph are the mixing times required to obtain an acceptable standard deviation in MH from batch to batch, comparing the various commercially available forms of di-*t*-butyl(peroxy) diisopropylbenzene.

Pre-dispersed peroxide masterbatches dramatically shorten mixing time and improve the quality of the elastomer by avoiding premature crosslinking or "scorch" in hard or soft compounds.

The final elastomeric composition exhibits a desirably lower and more consistent viscosity, essential to molding and extrusion operations.

Masterbatch peroxides are preferred in technical rubber articles production because they provide uniform peroxide dispersion and consistent physical properties.

ASPECT / PHYSICAL FORM

Masterbatch in pellets

Granules

Free-flowing powder

Crystals

APPLICATION

POLYMERS THAT CAN BE CROSSLINKED

- ABS Acrylonitrile butadiene styrene copolymer
- AU/EU Polyurethane rubber
- BR Polybutadiene rubber
- CM Chlorinated polyethylene
- CR Polychloroprene rubber
- CSM Chlorosulfonyl polyethylene
- EBA Ethylene butylacrylate copolymer
- EPM Ethylene propylene copolymer
- EPDM Ethylene propylene diene terpolymer
- EVA Ethylene vinylacetate copolymer
- FKM Fluoro rubber
- HNBR Hydrogenated butadiene acrylonitrile rubber
- IR Polyisoprene rubber
- NBR Butadiene acrylonitrile rubber
- NR Natural rubber
- PE Polyethylene
- POE Polyolefin elastomer
- Q Silicone rubber
- SBR Styrene butadiene rubber
- T Polysulfide rubber
- EEA Ethylene ethyl acrylate

POLYMERS THAT CANNOT BE CROSSLINKED

- ACM Polyacrylate rubber
- CIIR Chlorobutyl rubber
- CO Epichlorohydrin rubber
- ECO Epichlorohydrin copolymer
- IIR Butyl rubber
- PB Polybutene-1
- PIB Polyisobutene
- PVC Polyvinylchloride
- PP Polypropylene