



Nouryon

Hot press molding

Pressing SMC and BMC at elevated temperatures

Application data and cure data

Nouryon is the world's leading producer of organic peroxides for the curing of thermoset resins, coatings and specialty monomers. We're home to the best known brands in the thermoset market, examples include Butanox[®], Perkadox[®] and Trigonox[®]. We also have a whole range of auxiliary products, such as accelerators and promoters, to meet your specific production requirements.

This application guide introduces you to our thermoset product portfolio and helps you to find a suitable curing system for your specific application.

Application

Sheet Molding Compound (SMC) and Bulk Molding Compound (BMC) are intermediate products which are finally pressed to end products in a press at temperatures between 130 and 170°C.

During pressing it is possible to use an in-mold coating to finish the exterior of the product during the curing step.

Nouryon curing agents

The SMC/BMC material is prepared with a combination of peroxides and inhibitors to secure sufficient shelf life during storage and at the same time have high reactivity and efficient curing during pressing leading to low residual styrene levels and, if desired, obtain a high surface quality.

The main peroxides used in SMC/BMC are Trigonox 21S in combination with Trigonox C. Depending on the requirements of the end products alternatives could be Trigonox 21LS, which allows for longer storage stability of the SMC/BMC or Trigonox 141, Trigonox 117 or Trigonox BPIC-C75.

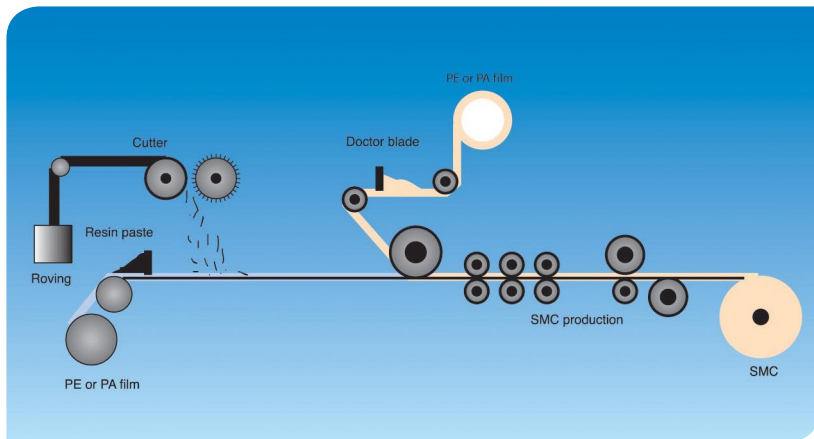
For PMC (in-mold Powder Coating) Perkadox BC formulations are used which are reactive at high curing temperatures.

Main products

The pressed end products in concern are very divers and include components for the automotive-, electrical- and building industry.

Reason for our products

- High quality
- Good aftersales and technical service
- Intensive safety research
- Worldwide distribution
- Customized application research: special formulated products for an optimal performance in this application
- Innovative focus on new developments



The process

The process to make SMC is schematically shown above. The process goes from left to right and start with a polymer sheet (PE or PA) on which the resin paste and chopped glass are fed. The resin paste is the formulation of resin containing peroxide, and / or accelerators, inhibitors, promoters, additives, pigments and filler. A top polymer sheet covers the SMC which is pressed and compacted after which it is rolled up. The roll is stored for a period of time to mature the compound and thicken it in in order to make it ready for use. Prior to pressing the required sheet size is cut out, the polymer sheets are removed and the sheet is put in the hot press. In a couple of minutes the sheet is pressed into its final shape.

The BMC process is not shown here but in that case almost the same components are mixed in a high shear mixer. This generates a fluffy flexible bulk mass that can be used in the hot press as well. The advantage here is that the flow of the product is easier and consequently also deep molds can be filled and cured.

Reactivity figures

Some of the reactivity data of the various peroxides are listed below.

Minimum molding time:

Measured in a 4 mm cup shaped molding at 140°C

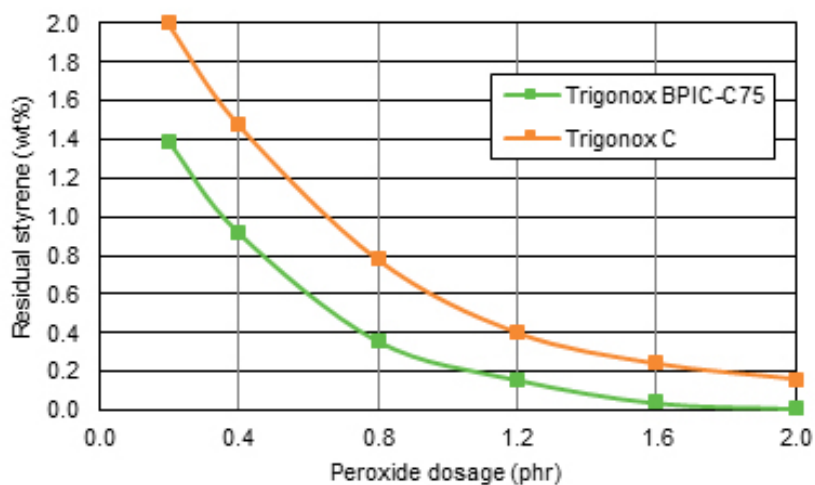
1.0 phr Trigonox C	60 sec.
1.0 phr Trigonox BPIC-C75	46 sec.

Residual styrene content:

Measured in a 4 mm cup shaped molding at 140°C after a molding time of the minimum molding time + 30 seconds.

1.0 phr Trigonox C	0.20%
1.0 phr Trigonox BPIC-C75	0.07%

Graph 1. The effect of the peroxide dosage level on the residual styrene content after a molding time of MMT + 30 sec. at 145°C of standard BMC formulations catalyzed with Trigonox C and Trigonox BPIC-C75



Cure system cure characteristics in 4 mm moldings

Table 1. Hot press molding experiments at 150°C with several peroxides and peroxide combinations in a low shrink BMC formulation based on polystyrene

CURE SYSTEM	67MOLDING TEMPERATURES 150°C			
	MAX. FLOW TIME (MFT)	MIN. MOLDING TIME (MMT)	TOTAL MOLDING TIME MMT + 90 SEC.	
			GLOSS (SEC.)	RESIDUAL STYRENE (%)
1.5 phr Trigonox 29-IN50	18	36	66	0.62
1.5 phr Trigonox BPIC-C75	21	41	63	0.12
1.5 phr Trigonox 42S	22	41	65	0.42
1.5 phr Trigonox C	25	48	69	0.10
1.25 phr Trigonox 29-IN50 + 0.25 phr Trigonox 21S	15	30	76	0.67
1.25 phr Trigonox BPIC-C75 + 0.25 phr Trigonox 21S	15	30	72	0.18
1.25 phr Trigonox 42S + 0.25 phr Trigonox 21S	15	29	72	0.45
1.25 phr Trigonox C + 0.25 phr Trigonox 21S	15	30	75	0.17

Problems and solutions

Reaching low VOC and low residual styrene levels

Low VOC levels as is required by the automotive industry can be reached with a special cure system, i.e. a combination of Trigonox 21S, Trigonox 117 and Cobalt plus the use of a low shrink or a low profile additive. After pressing the residual styrene levels should be below 0.1%, the benzene level should be below 1 ppm, the smell level should be below 3 and the VOC level should be below 100 ppm. These values all depend on the requirements mentioned in the used methods to determine the specific parameters. Further details on intakes and process settings are available on request.

Traces of benzene

Trigonox C is the most commonly used peroxide for HPM. A disadvantage can be the presence of a small amount of benzene in the end-product after cure. Benzene is a decomposition product of Trigonox C. To assure zero benzene emissions we recommend using a different peroxide like Trigonox 117 or Trigonox 42S. These are aliphatic molecules and do not contain an aromatic ring as part of their molecule.

Reducing the pressing temperature

To reduce the pressing temperature we recommend using a high reactive peroxide like Trigonox 21S. Trigonox 21S however does not have an efficient cure. Efficient curing can be achieved by using efficient peroxides such as Trigonox 117, Trigonox BPIC-C75 or Trigonox C. The optimum process setting for a fast and efficient curing is therefore to use a combination of Trigonox 21S with Trigonox C or Trigonox 117 or Trigonox BPIC-C75. Adding a small amount of cobalt to resin formulations based on peresters (like Trigonox 21S, Trigonox C and Trigonox 42S) will increase the reactivity, but also decrease the shelf-life of the compounds.

Shelf life of the SMC/BMC / influence of pigments or carbon blacks

Perketales like Trigonox 29-C50 or Trigonox 22-C50 are well known to have a very long shelf life (over 6 months at 30°C) in the compound. Also the reactivity and shelf life of the compound is less affected by pigments and carbon black when perketales are used in the formulation.

If you use a fast peroxide like Trigonox 21S then you can improve the shelf life of the SMC/BMC by switching to Trigonox 21LS which contains an inhibitor to improve the shelf life of the compound without affecting the reactivity. Also addition of Inhibitor NLD-20 will give the same effect.

Better gloss

Better gloss can be achieved by using a combination of two peroxides, a fast kicker peroxide with a low activation T (like Trigonox 21S) in combination with a second peroxide which has a high efficiency (a perester like Trigonox C). The combination of the two will assure a fast cure and an improved gloss. The use of a low profile additive will also help to improve the gloss but might lead to increased residual styrene levels.

A summary containing the standard reactivity data of the most used products in this application can be found on the next pages.

Cure data

Trigonox 21S

Trigonox 21S, tert-butyl peroxy 2 ethylhexanoate, is a perester which is used for the curing of unsaturated polyester resin at elevated and high temperatures.

Trigonox 21S is preferred for the curing of UP resin based Hot Press Molding formulation (such as SMC and BMC) in the temperature range of 120 - 160°C. As Trigonox 21S is a high reactive peroxide, it is very suitable as a kicker in formulations for pultrusion and SMC/BMC.

In combination with a cobalt accelerator, Trigonox 21S is also applicable for the cure of UP resins in the temperature range of 60°C and higher. Application area can be air drying lacquers, diplacquers, wall panels, filament winding, etc.

Trigonox 21S has normally a much shorter pot life in the pure resin than Trigonox C, tert-butyl peroxybenzoate

Dosing

Depending on working conditions, the following dosage levels are recommended:

Trigonox 21S

1 - 2 phr *

Accelerator NL-49PN

0.5 - 3 phr

*(parts per hundred resin)

Cure characteristics in pure UP resin

In a high reactive standard orthophthalic UP resin the following application characteristics were determined:

Activation temperature

1 phr Trigonox 21S	60°C
1 phr Trigonox 21S + 1 phr Acc. NL-49PN	50°C

Pot life at 20°C

1 phr Trigonox 21S	22 days
1 phr Trigonox C	56 days
1 phr Trigonox 21S + 1 phr Acc. NL-49PN	5 days
1 phr Trigonox C + 1 phr Acc. NL-49PN	17 days

For the application at elevated temperatures the following reactivity data give an idea of the performance:

Time-Temperature curves at 70°C and 90°C

	CURE TEMP MIN	GEL TIME MIN.	TIME TO PEAK MIN.	PEAK EXOTHERM (°C)
1 phr Trigonox 21S	70	9	16	233
1 phr Trigonox 21S + 1 phr Accelerator NL-49PN	70	3	5	214
1 phr Trigonox 21S	90	1	6	258
1 phr Trigonox 21S + 1 phr Accelerator NL-49PN	90	0.3	1.5	240

Cure characteristics in Hot Press Molding

In a standard Hot Press Molding (HPM) compound based on a high reactive orthophthalic polyester resin with calcium carbonate as filler and magnesium oxide as thickening agent, the following application characteristics were determined:

Shelf life at 30°C

	not pigmented	+ 5 phr iron oxide black
1 phr Trigonox 21S	14 days	4 days
1 phr Trigonox C	47 days	17 days

Platen gel time

	Mold temperature	
	120°C	140°C
1 phr Trigonox 21S	13 s	5 s
1 phr Trigonox C	85 s	22 s

Minimum molding time

Measured in a 4 mm cup shaped molding at 140°C.

1 phr Trigonox 21S	15 s
1 phr Trigonox C	60 s

Trigonox C

Trigonox C, tert-butyl peroxybenzoate, is an aromatic perester, which is used for the curing of unsaturated polyester resins at elevated temperatures.

Trigonox C is preferred for the curing of UP resin based Hot Press Molding formulations (SMC, BMC etc.) in the temperature range of 120-170°C.

Trigonox C can also be used in combination with high reactive peroxides like Perkadox 16 or Trigonox HMa as kicker in formulations for pultrusion in the temperature range of 100-150°C.

In combination with a cobalt accelerator (e.g. Accelerator NL-53N, 10% cobalt), Trigonox C is also applicable for the cure of UP resins in the temperature range of 70°C and higher. Application area can be: air drying lacquers, diploquers, filament winding, etc.

Dosing

Depending on application and working conditions, the following peroxide and when applicable cobalt accelerator dosage levels are recommended:

Trigonox C

1 - 2 phr *

*(parts per hundred resin)

Accelerator NL-53N

0.1 - 0.6 phr

Cure characteristics in pure UP resin

In a high reactive standard orthophthalic UP resin the following application characteristics were determined:

Activation temperature

1 phr Trigonox C	80°C
1 phr Trigonox C + 0.1 phr Acc. NL-53N	70°C

Pot life at 20°C

1 phr Trigonox C	56 days
1 phr Trigonox C + 0.1 phr Acc. NL-53N	17 days

For the application at elevated temperatures the following data determined in 25 g pure UP resin can be used as an indication of the reactivity:

Time-temperature curves at 90°C

	GEL TIME MIN.	TIME TO PEAK MIN.	PEAK EXOTHERM (°C)
1 phr Trigonox C	9	25	236
1 phr Trigonox C + 0.1 phr Accelerator NL-53N	2	6	258

Cure characteristics in Hot Press Molding

In a standard Hot Press Molding compound based on a high reactive orthophthalic polyester resin with calcium carbonate as filler and magnesium oxide as thickening agent, the following application characteristics were determined:

Shelf life at 30°C

	not pigmented	+ 5 phr iron oxide black
1 phr Trigonox C	47 days	17 days

Platen gel time

	Mold temperature
	120°C 140°C
1 phr Trigonox C	85 sec. 22 sec.

Trigonox 21LS

Trigonox 21LS is a perester formulation based on tert-butylperoxy-2-ethylhexanoate, which is used for the curing of unsaturated polyester resin at elevated temperatures.

Trigonox 21LS is preferred for the curing of UP resin based Hot Press Molding formulations (SMC, DMC, BMC, etc) in the temperature range of 120 - 160°C.

As Trigonox 21LS is a high reactive peroxide, it is very suitable as a kicker in formulations for pultrusion and SMC/BMC in combination with peroxides like Trigonox C and Trigonox 29-C50.

Trigonox 21LS gives in comparison with Trigonox 21S a long shelf life stability of the compound, without affecting the cure speed, even when iron oxides or carbon black are used as pigment.

Dosing

Depending on working conditions, the following peroxide and when applicable cobalt accelerator dosage levels are recommended:

**Trigonox 21LS
as such
1 - 2 phr ***

**Trigonox 21LS
as kicker
0.5 - 3 phr**

*(parts per hundred resin)

Cure characteristics in pure UP resin

In a high reactive standard orthophthalic UP resin the following application characteristics were determined:

Activation temperature

1 phr Trigonox 21LS	60°C
1 phr Trigonox 21S	60°C

Pot life at 20°C

1 phr Trigonox 21LS	80 days
1 phr Trigonox 21S	2 days
1 phr Trigonox C	56 days

Cure characteristics in Hot Press Molding

In a standard Hot Press Molding compound based on a high reactive orthophthalic polyester resin with calcium carbonate as filler and magnesium oxide as thickening agent, the following application characteristics were determined:

Shelf life at 30°C

	not pigmented	+ 5 phr iron oxide black
1 phr Trigonox 21LS	50 days	38 days
1 phr Trigonox 21S	14 days	4 days
1 phr Trigonox C	47 days	17 days

Platen gel time

	Mold temperature	
	120 °C	140°C
1 phr Trigonox 21LS	16 s.	5 s.
1 phr Trigonox 21S	13 s.	5 s.
1 phr Trigonox C	85 s.	22 s.

Minimum Molding time

Measured in a 4 mm cup shaped molding at 140°C

1.0 phr Trigonox 21LS	15 s.
1.0 phr Trigonox 21	15 s.
1.0 phr Trigonox C	60 s.

Trigonox 141

Trigonox 141, 2,5-Dimethyl-2,5-di(2-ethylhexanoylperoxy)hexane, is a di-functional perester which is used for the curing of unsaturated polyester resins at high temperatures.

Trigonox 141 is preferred for the curing of UP resin based Hot Press Molding formulations (such as DMC and BMC) in the temperature range of 120 - 160°C.

Trigonox 141 is preferably used in combination with a low reactive peroxide like Trigonox C or Trigonox BPIC-C75 and an optimal low profile SMC formulation for the production of HPM parts with a Class A surface at short molding times.

Dosing

Depending on application and working conditions the following peroxide and when applicable cobalt accelerator dosage levels are recommended:

**Trigonox 141
as such
1 - 2 phr ***

**in combination with a low
reactive peroxide
0.25 - 1 phr**

*(parts per hundred resin)

Cure characteristics in pure UP resin

In a high reactive standard orthophthalic UP resin the following application characteristics were determined:

Activation temperature

1 phr Trigonox 141 60°C

Cure characteristics in Hot Press Molding

In a standard Hot Press Molding compound based on a high reactive orthophthalic polyester resin with calcium carbonate as filler and magnesium oxide as thickening agent, the following application characteristics were determined:

Shelf life at 30°C

	not pigmented	+ 5 phr iron oxide black
1 phr Trigonox 141	9 days	7 days
1 phr Trigonox 21	14 days	4 days
1 phr Trigonox C	47 days	17 days

Platen gel time

	Mold temperature	
	120°C	140°C
1 phr Trigonox 141	12 s	4 s
1 phr Trigonox 21	13 s	5 s
1 phr Trigonox C	85 s	22 s

Minimum Molding Time

Measured at a 4 mm cup shaped molding at 140°C

1 phr Trigonox 141	13 s
1 phr Trigonox 21	15 s
1 phr Trigonox C	60 s

Trigonox 117

Trigonox 117, tert-butylperoxy 2-ethylhexyl carbonate, is an aliphatic peroxide that is used for the curing of unsaturated polyester resins at elevated temperatures.

Trigonox 117 is preferred for the curing of UP resin based Hot Press Molding formulations (SMC, DMC, BMC, etc) in the temperature range of 120 - 170°C.

Trigonox 117 is especially recommended for the production of SMC/ BMC parts, which find their application in the innercompartment of cars.

Trigonox 117 gives a comparable amount of volatile decomposition products during the cure reaction as Trigonox C, tert-butyl peroxybenzoate, however, without benzene.

Trigonox 117 can also be used as 'finishing' peroxide in combination with high reactive peroxides like Perkadox 16 or Trigonox HM as 'kicker' in formulations for pultrusion in the temperature range of 100-150°C.

Dosing

Depending on application and working conditions the following peroxide and cobalt accelerator dosage levels are recommended:

Trigonox 117

1 - 2 phr *

*(parts per hundred resin)

Cure characteristics in pure UP resin

In a high reactive standard orthophthalic UP resin the following application characteristics were determined:

Activation temperature

1 phr Trigonox 141 60°C

Cure characteristics in Hot Press Molding

In a high reactive standard orthophthalic UP resin the following application characteristics were determined:

Activation temperature

1 phr Trigonox 117 80°C

Pot life at 20°C

1 phr Trigonox 117 60 days

Cure characteristics in Hot Press Molding

In a standard Hot Press Molding compound based on a high reactive orthophthalic polyester resin with calciumcarbonate as filler and magnesium oxide as thickening agent, the following application characteristics were determined:

Shelf life at 30°C

1 phr Trigonox 117	not pigmented	+ 5 phr iron oxide black
	49 days	25 days

Platen gel time

	Mold temperature	
	120°C	140°C
1 phr Trigonox 117	85 s	22 s

Minimum molding time

Measured in a 4 mm cup shaped molding at 140°C

1 phr Trigonox 117	59 s
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Trigonox BPIC-C75

Trigonox BPIC-C75, tert-butylperoxy isopropyl carbonate, is an aliphatic percarbonate, which is used for the curing of unsaturated polyester resins at elevated temperatures.

Trigonox BPIC-C75 is especially developed for the curing of UP resin based Hot Press Molding formulations (SMC, DMC, BMC etc) in the temperature range of 120 - 170°C.

Trigonox BPIC-C75 gives a long shelf life stability of the compound.

Trigonox BPIC-C75 can in comparison with Trigonox C, tert-butyl peroxybenzoate, be characterized as a faster and more efficient peroxide. This means a faster and more optimal cure with a lower residual styrene content of the molded part. In combination with an optimal Low Profile or Low Shrink formulation a very smooth and regular surface of the molded product can be achieved.

The decomposition products of Trigonox BPIC-C75 are low volatile compounds, which makes the peroxide very suitable for the production of e.g. microwave cookware. For a further increase of the reactivity, Trigonox BPIC-C75 can be used in combination with a high reactive peroxide like Trigonox 21 or Trigonox 141.

Dosing

Depending on application and working conditions, the following peroxide dosage level is recommended:

Trigonox BPIC-C75

1 - 2 phr *

*(parts per hundred resin)

Cure characteristics in pure UP resin

In a high reactive standard orthophthalic UP resin the following application characteristics were determined:

Activation temperature

1 phr Trigonox BPIC-C75	80°C
1 phr Trigonox C	80°C

Pot life at 20°C

1 phr Trigonox BPIC-C75	71 days
1 phr Trigonox C	56 days

Cure characteristics in Hot Press Molding

In a standard Hot Press Molding compound based on a high reactive orthophthalic polyester resin with calcium carbonate as filler and magnesium oxide as thickening agent, the following application characteristics were determined:

Shelf life at 30°C

	not pigmented	+ 5 phr iron oxide black
1 phr Trigonox BPIC-C75	50 days	35 days
1 phr Trigonox C	47 days	17 days

Platen gel time

	Mold temperature	
	120°C	140°C
1 phr Trigonox BPIC-C75	56 sec.	17 sec.
1 phr Trigonox C	85 sec.	22 sec.

Minimum molding time

Measured in a 4 mm cup shaped molding at 140°C.

1.0 phr Trigonox BPIC-C75	46 sec.
1.0 phr Trigonox C	60 sec.

Residual styrene content

The residual styrene content has been measured in a 4 mm cup shaped molding at 140°C after a molding time of minimum molding time plus 30 seconds.

1.0 phr Trigonox BPIC-C75	0.07%
1.0 phr Trigonox C	0.20%

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Additional information

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

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Nouryon

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