Introduction
AkzoNobel 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. If you need more detailed information please contact us.

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.

AkzoNobel 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 21 LS, which allows for longer storage stability of the SMC/BMC or Trigonox 141, Trigonox 117 or Trigonox BPI-C75.

For PMC (in-mold Powder Coating) Perkadox 14 and Perkadox BC 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 starts 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 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 (injection) 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

<table>
<thead>
<tr>
<th>Cure system</th>
<th>Max. flow time (MFT)</th>
<th>Min. molding time (MMT)</th>
<th>Total molding time MMT + 90 sec.</th>
<th>Gloss</th>
<th>Residual styrene (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 phr Trigonox 29-IN50</td>
<td>18</td>
<td>36</td>
<td>66</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>1.5 phr Trigonox BPIC-C75</td>
<td>21</td>
<td>41</td>
<td>63</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>1.5 phr Trigonox 42S</td>
<td>22</td>
<td>41</td>
<td>65</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>1.5 phr Trigonox C</td>
<td>25</td>
<td>48</td>
<td>69</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>1.25 phr Trigonox 29-IN50+ 0.25 phr Trigonox 21S</td>
<td>15</td>
<td>30</td>
<td>76</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>1.25 phr Trigonox BPIC-C75 + 0.25 phr Trigonox 21S</td>
<td>15</td>
<td>30</td>
<td>72</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>1.25 phr Trigonox 42S + 0.25 phr Trigonox 21S</td>
<td>15</td>
<td>29</td>
<td>75</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>1.25 phr Trigonox C + 0.25 phr Trigonox 21S</td>
<td>15</td>
<td>30</td>
<td>67</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>
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 benzene 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.