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®, Cadox®, Perkadox® and Trigonox®. We also have a whole range of specialty auxiliary products, such as cobalt free accelerators to meet specific production requirements.

This application guide provides an introduction to our thermoset product portfolio and can help you find a suitable curing system for your specific application. If you need more detailed information please contact your account manager or customer service representative. Sharing our thermoset experience is one of the biggest resources we offer.

Application
Perkadox 16 is a commonly used peroxide for pultrusion, has been primarily replaced by Perkadox 16-40XPS which is a pourable paste with significantly improved safety, handling & storage properties. The performance of this 40% active suspension is virtually identical to Perkadox 16 on an active peroxide basis. Perkadox 16-40XPS should be used at the same active oxygen loading level as Perkadox 16.

AkzoNobel curing agents
For climate conditions common in America, we recommend the use of Perkadox 16 or Perkadox 16-40XPS Trigonox 21S, and Trigonox C or Trigonox 29-C50. Normally these are used in combination to make full use of the specific reactivity of the various peroxides.

Main products
The main products which are manufactured by pultrusion process are profiles and rods which find their use in steps, grids, handles, windows etc.
Process equipment
The pultrusion process is a continuous production method for highly filled polyester profiles. Basically in this process: reinforcement material, impregnated with a binder resin is pulled through a heated die for shaping and curing. Composition: 25-50 parts high reactive UP resin and 75-50 parts glass reinforcement + additives (filler, pigments, flame retardants).

The glass reinforcement is in general roving or spin roving, but can also be glasmat, glass cloth or a combination. The impregnation of the reinforcement material is done by pulling the glass through a resin bath (outside) or by injecting the resin in the glass in the die. The dies are generally made of chrome plated steel with a length of about 50-150 cm.

Curing System
The gelation and curing takes place in the die at a temperature of e.g. 100-160°C, with a production speed of 0.25-2 m/min. The choice of the curing system is dependent on parameters like profile shape, thickness, die-temperature, profile composition and resin reactivity.

The curing system is chosen in a way that the pot-life of the premix is long enough for the intended equipment. This means that the peroxides should have a low enough reactivity at ambient temperature for the pot-life desired. At the same time, the reactivity should be high enough in the heated die. This requires a peroxide with a low activation temperature like Perkadox 16, Perkadox 16-40XPS or Trigonox 21S. These are known as kicker peroxides as they initiate the curing and propagate the initial temperature rise needed to initiate the secondary & tertiary peroxides in the curing system. These kicker peroxides are however not very efficient and do not finish off the reaction. The curing process should be completed with medium and high temperature peroxides to reduce residual styrene levels close to zero once the profile leaves the die. This requires use of a more efficient higher temperature peroxide like Trigonox C or Trigonox 29-C75.

Consequently a curing system for pultrusion always contains at minimum a kicker peroxide and a more efficient higher temperature peroxide, Perkadox 16 + Trigonox C for example is commonly used. But other combinations are possible as well. For simple uniform thickness geometries, Perkadox CH-50 can be used as the kicker peroxide.
Reactivity figures
(curing systems for regions with moderate ambient temperatures)

Perkadox 16

Time-temperature curves
Time-temperature curves have been determined at 60°C, 100°C and 140°C to demonstrate the use of Perkadox 16 as kicker in pultrusion applications. From the curves the time to peak was calculated as an indication for the cure speed.

<table>
<thead>
<tr>
<th>Catalyst Combination</th>
<th>Time to Peak at 60°C</th>
<th>Time to Peak at 100°C</th>
<th>Time to Peak at 140°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 phr Trigonox 29-C50</td>
<td>5.5</td>
<td>7.7</td>
<td>2.8</td>
</tr>
<tr>
<td>1 phr Trigonox 29-C50 + 1 phr Perkadox 16</td>
<td>0.25</td>
<td>2.4</td>
<td>1.4</td>
</tr>
<tr>
<td>1 phr Trigonox C</td>
<td>24</td>
<td>13.5</td>
<td>3.5</td>
</tr>
<tr>
<td>1 phr Trigonox C + 1 phr Perkadox 16</td>
<td>0.25</td>
<td>2.1</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Graph 1. Peak exotherm in 5 mm laminates cured with 1.5 phr of different ratio of Perkadox 16 and Trigonox C at 90-120-150°C

Graph 2. The peak exotherm of the time temperature curve in 5 mm laminates cured with 0.5 phr Perkadox 16 + different finishing catalysts at 90°C and 120°C

Tx = Trigonox; Px = Perkadox
Reactivity figures
(curing systems for regions with higher ambient temperatures)

Perkadox CH-50X

Time-temperature curves
Time-temperature curves have been determined at 60°C, 100°C and 140°C to demonstrate the use of Perkadox CH-50X as kicker in pultrusion applications. From the curves the time to peak was calculated as an indication for the cure speed.

<table>
<thead>
<tr>
<th></th>
<th>60°C (hours)</th>
<th>100°C (min.)</th>
<th>140°C (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 phr Trigonox C</td>
<td>24</td>
<td>13.5</td>
<td>3.5</td>
</tr>
<tr>
<td>1 phr Trigonox C + 0.5 phr Perkadox CH-50X</td>
<td>12.6</td>
<td>9.0</td>
<td>2.1</td>
</tr>
</tbody>
</table>

For more information

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