Crosslinking peroxides for elastomers and thermoplastics

Perkadox® and Trigonox®
A complete range of crosslinking peroxides

Nouryon’s range of organic peroxides for the crosslinking of elastomers and thermoplastics is very extensive. Companies all over the world depend on our Trigonox® and Perkadox® organic peroxide brands. Why? Because they are an important ingredient in the production of everything from hi-tech automotive parts such as hoses and belts to shoe soles and power distribution cables.

Examples include:
- **Trigonox 311**
  PEX pipes, rotomolding
- **Trigonox 145**
  PEX pipes, rotomolding
- **Trigonox 101**
  PEX pipes, polymer modification, technical rubber goods
- **Trigonox T**
  wire & cable (direct peroxide injection)
- **Perkadox 14**
  wire & cable, technical rubber goods, footwear
- **Perkadox BC**
  wire & cable, footwear, technical rubber goods
- **Trigonox 117 and Trigonox 131**
  for EVA and POE encapsulant films
- **Trigonox 29**
  for fast on-set of cure
- **Perkadox PM-50S-ps**
  extruded silicone rubber articles such as silicone rubber cable, seals & tubes (halogen free)

Much of our success is due to our philosophy of creating close partnerships with our customers. What do you want to achieve? From optimizing applications, improving efficiencies, resolving difficulties or even developing new crosslinking peroxides, we’re happy to meet with you to discuss your requirements.

This product guide provides an overview of our main, commercially available crosslinking peroxides. We invite you to visit us at www.nouryon.com for complete product listings.

Formulations with phlegmatizers and carriers or concentrations other than those indicated, as well as unique custom made peroxide compositions can be made available with due observance of safety characteristics and the appropriate environmental and transportation regulations. Whatever your particular requirements, we can develop the product to match.
<table>
<thead>
<tr>
<th>Product name</th>
<th>Chemical name [CAS no.]</th>
<th>Mol. weight</th>
<th>Assay (%)</th>
<th>Main carrier / solvent</th>
<th>Safe processing temperature (°C)</th>
<th>Typical crosslink temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigonox 311</td>
<td>3,3,5,7,7-Pentamethyl-1,2,4-trioxepane [215877-64-8]</td>
<td>174.3</td>
<td>95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonox 145-E8S</td>
<td>2,5-Dimethyl-2,5-di(tert-butylperoxy)hexyne-3 [1068-27-5]</td>
<td>286.4</td>
<td>85</td>
<td>mineral oil</td>
<td>145</td>
<td>185</td>
</tr>
<tr>
<td>Trigonox B</td>
<td>Di-tert-butyl peroxide [110-05-4]</td>
<td>146.2</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonox 101</td>
<td>2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane [78-63-7]</td>
<td>290.4</td>
<td>&gt;92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonox 101-50D-PD</td>
<td>tert-Butyl cumyl peroxide [3457-61-2]</td>
<td>208.3</td>
<td>95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigonox T</td>
<td>Diter-butyloxypivaldehyde [25155-25-3; 2212-81-9]</td>
<td>338.5</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perkadox BC-FF</td>
<td>Dicumyl peroxide [80-43-3]</td>
<td>270.4</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Trigonox B has a boiling point of 110°C and a flash point of 6°C. Therefore, this product is not recommended for standard rubber.

2 Other concentrations are available on request.
<table>
<thead>
<tr>
<th>Product name</th>
<th>Chemical name [CAS no.]</th>
<th>Mol. weight</th>
<th>Assay (%)</th>
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<th>Safe processing temperature (°C)</th>
<th>Typical crosslink temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyl 4,4-difert-butyroxyvalerate [995-33-5]</td>
<td>334.5</td>
<td>40</td>
<td>calcium carbonate</td>
<td>125</td>
<td>160</td>
<td></td>
</tr>
<tr>
<td>tert-Butylperoxy 2-ethylhexyl carbonate [34443-12-4]</td>
<td>246.3</td>
<td>&gt;98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tert-Amylperoxy 2-ethylhexyl carbonate [70833-40-8]</td>
<td>260.4</td>
<td>&gt;94</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tert-Butyl peroxybenzoate [614-45-9]</td>
<td>194.2</td>
<td>98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(4-methylbenzoyl) peroxide [895-85-2]</td>
<td>270.3</td>
<td>85</td>
<td>silicone oil</td>
<td>110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dibenzoyl peroxide [94-36-0]</td>
<td>242.2</td>
<td>85</td>
<td>silicone oil</td>
<td>105</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D(2,4-dichlorobenzoyl) peroxide [133-14-2]</td>
<td>380.0</td>
<td>75</td>
<td>silicone oil</td>
<td>90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Recommended dosage levels

<table>
<thead>
<tr>
<th>Peroxide</th>
<th>Trigonox 29-40</th>
<th>Trigonox 17-40</th>
<th>Perkadox BC-40</th>
<th>Perkadox 14-40</th>
<th>Trigonox 101-45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe processing temperature (°C)</td>
<td>115</td>
<td>125</td>
<td>130</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>Typical crosslink temperature (°C)</td>
<td>145</td>
<td>160</td>
<td>170</td>
<td>175</td>
<td>175</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Polymer</th>
<th>parts of peroxide per 100 parts of polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR, IR</td>
<td>2.3 - 4.5, 2.5 - 5.0, 2.0 - 4.1, 1.3 - 2.5, 1.3 - 2.4</td>
</tr>
<tr>
<td>BR</td>
<td>1.0 - 2.1, 1.1 - 2.3, 0.9 - 1.9, 0.5 - 1.2, 0.5 - 1.2</td>
</tr>
<tr>
<td>CR</td>
<td>1.1 - 3.0, 1.3 - 3.3, 1.0 - 2.7, 0.6 - 1.7, 0.6 - 1.6</td>
</tr>
<tr>
<td>SBR</td>
<td>1.9 - 4.1, 2.1 - 4.6, 1.7 - 3.7, 1.1 - 2.3, 1.1 - 2.2</td>
</tr>
<tr>
<td>NBR</td>
<td>2.6 - 4.5, 2.9 - 5.0, 2.4 - 4.1, 1.5 - 2.5, 1.4 - 2.4</td>
</tr>
<tr>
<td>HNBR</td>
<td>6.8 - 11.3, 7.5 - 12.5, 6.1 - 10.1, 3.8 - 6.3, 3.7 - 6.1</td>
</tr>
<tr>
<td>POE1</td>
<td>6.8 - 11.3, 7.5 - 12.5, 6.1 - 10.1, 3.8 - 6.3, 3.7 - 6.1</td>
</tr>
<tr>
<td>EPM2, EPDM</td>
<td>6.8 - 11.3, 7.5 - 12.5, 6.1 - 10.1, 3.8 - 6.3, 3.7 - 6.1</td>
</tr>
<tr>
<td>PE</td>
<td>1.5 - 7.6, 1.7 - 8.4, 1.4 - 6.8, 0.8 - 4.2, 0.8 - 4.0</td>
</tr>
<tr>
<td>CM3</td>
<td>6.8 - 10.6, 7.5 - 11.7, 6.1 - 9.5, 3.8 - 5.9, 3.7 - 5.7</td>
</tr>
<tr>
<td>EVA</td>
<td>2.6 - 5.3, 2.9 - 5.8, 2.4 - 4.7, 1.5 - 3.0, 1.4 - 2.9</td>
</tr>
<tr>
<td>Q4</td>
<td>1.0 - 2.0, 1.0 - 2.0, 0.4 - 0.8, 0.4 - 0.8</td>
</tr>
</tbody>
</table>

1. Addition of a coagent is recommended.
2. Silicone rubber can also be crosslinked with Perkadox PD-50S, Perkadox L-50S and Perkadox PM-50S.

### Peroxide versus sulfur crosslinking

**Advantages of peroxide crosslinking in comparison to sulfur cure:**
- Simple formulation.
- Relatively easy to trace decomposition products.
- Storage of the peroxide-containing compound without bin scorch.
- High processing temperature.
- Rapid vulcanization without reversion.
- Good compression set, particularly at elevated temperatures.
- High temperature resistance.
- Limited extractable constituents from final product.
- No staining of the finished parts.
- No discoloration of crosslinked product by contact with metals and PVC.
- Most peroxides do not cause blooming.
- Co-vulcanization of saturated and unsaturated elastomers.
- Co-vulcanization of elastomers and thermoplastics.
- Copolymerization with polymerizable plasticizers or coagents to give controlled hardness and stiffness, coupled with easy processing.
- Zinc oxide-free formulations possible.

**Points of attention for peroxide crosslinking:**
- Sensitivity to oxygen under curing conditions.
- Certain components of the rubber compound such as fillers, extender oils, antioxidants, resins must be selected with care because they may, under certain conditions, interfere with free radicals.
- Usually, tensile and tear strength properties are reduced by about 15%, when compared to a conventional sulfur based crosslinking system.
- Scorch and cure time are less flexible, since they are determined mainly by the temperature.
- During cure, some peroxides may lead to distinct odors.
- Post cure may be necessary.
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Additional information
Product Data Sheets (PDS) and Safety Data Sheets (SDS) for our polymer crosslinking products are available at nouryon.com

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