Crosslinking

of rubber and polyolefines
with organic peroxides
The Peroxide Company
For more than 40 years your partner for organic peroxides

Since its foundation in 1981, Pergan has established itself in the national and international market as a manufacturer of organic peroxides.

With production facilities in Germany and the United States and a joint-venture in China we foster constructive and trusting business connections with our national and international customers.

Customer orientation – a recipe for success

Part of our service also includes examining our customers’ applications so that we can develop optimal product formulations and supply them with suitable peroxide- and other additive preparations for their process. Therefore we do not offer only products but moreover solutions to problems. The positive feedback from satisfied customers motivates us to keep continuing along this line.

Competent

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Reliable

Quality does not only mean reliability but also includes services such as consultation and support for our customers helping them to solve their problems. Quality results from the performance of all employees. We work towards strengthening quality awareness through the help of information, internal and external training and motivation.

Flexible

As a medium sized company flexibility is one of our greatest strengths. We are able to react quickly, competently and efficiently to the individual wishes and requirements of our customers. In recognition of exceptional business achievements PERGAN was awarded the jury award „Company of the Year 2010“ by Stadtsparkasse Bocholt.

Safety first and environmental conservation for PERGAN out of responsibility

Organic peroxides are highly reactive chemicals. The manufacturing, transport, storage, handling and last but not least the disposal of organic peroxides requires strict precautions. We have effected considerable investments into safety to eliminate risks, to avoid faults and to protect people and environment from becoming endangered. Naturally, we provide our customers support in any kind of safety, handling, or storage issue.

Organic peroxides
The main stress of our business activity is put on the production and trade of organic peroxides. These are more or less stable chemical compounds which exclusively consist of carbon, hydrogen and oxygen. They are used as initiators and reaction substances in the plastics and rubber industry, because they easily decay in extremely active radicals.

Organic peroxides are used for:

• polymerization of monomers for plastics manufacture
• crosslinking and modification of polymers,
• as the curing of unsaturated polyester-, vinylester- and acrylic resins

Organic peroxides are furthermore used as oxidation materials for medical preparations and for complicated chemical synthesis.

Our company holds ISO 9001 and ISO 14001 certification
### Crosslinking of rubber and polyolefines with organic peroxides

Chemical crosslinking agents such as sulphur and organic peroxides are able to link polymer chains creating a three-dimensional network. This crosslinking reaction changes several material characteristics. The material characteristics of a crosslinked polymer are superior to the equivalent characteristics of the sulphur cured polymers.

### Peroxide crosslinking of elastomers has the following advantages over the sulphur cure:

- Simple formulation
- Long storage time of the peroxide
- Containing compound without scorching
- High processing temperature
- Rapid vulcanization without reversion
- High temperature resistance of final product
- Crosslinked products do not change colour
- Through contacts with metals and PVC
- Most peroxides do not cause blooming
- Co-vulcanization of saturated and unsaturated rubbers
- Co-vulcanization of rubbers with polyethylene
- And other polyolefins
- Co-polymerisation with polymerisable plasticisers
- Or other co-agents to achieve a controlled hardness
- And stiffness coupled with easy processing

### In comparison to sulphur cure there are following disadvantages:

- Sensitivity to oxygen under curing conditions
- Certain components of the rubber compound like extender oils, antioxidants and resins may consume peroxide free radicals under certain conditions
- Usually tensile and tear strength properties are reduced by 15%

### Typical amounts of organic peroxides required for crosslinking of various polymers

Additions of the important peroxides for the crosslinking of different types of polymers are listed on the next page. Satisfactory mechanical properties can be obtained at the lowest peroxide dosage levels. Compression set properties improve with higher peroxide amounts. The highest values should not be surpassed, otherwise the remaining mechanical properties will decrease. However, higher peroxide levels are necessary when the compound contains free radical consuming materials such as sulphur, certain antioxidants and non-paraffinc, mineral extender oils.

### Chlorine-free crosslinker for silicone rubber

PEROXAN PMB Paste 50 SI is used for chlorine-free crosslinking of silicone rubber (extrusion). The paste is an alternative to the well known dib- (2,4-dichlorobenzoyl) peroxide paste (DCLBP), which has come under discussion due to the decomposition product polychlorinated biphenyls (PCB). When crosslinked with PEROXAN PMB Paste 50 SI the peroxide decomposes into chlorine-free decomposition products, means no polychlorinated biphenyls (PCB) are formed.

### Parts of peroxide per 100 parts of polymer

<table>
<thead>
<tr>
<th>Polymer</th>
<th>Parts of PEROXAN PK225 P</th>
<th>Parts of PEROXAN DC-40 P</th>
<th>Parts of PEROXAN BB-40 P</th>
<th>Parts of PEROXAN HV-4/5 P</th>
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<tbody>
<tr>
<td>NR, IR</td>
<td>2.3 - 4.5</td>
<td>2.0 - 4.1</td>
<td>1.3 - 2.5</td>
<td>1.5 - 2.4</td>
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<td>BB</td>
<td>1.0 - 2.1</td>
<td>0.9 - 1.9</td>
<td>0.5 - 1.2</td>
<td>0.8 - 1.2</td>
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<td>CR</td>
<td>1.1 - 3.0</td>
<td>1.0 - 2.7</td>
<td>0.6 - 1.7</td>
<td>0.6 - 1.6</td>
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<td>SBR</td>
<td>1.9 - 4.1</td>
<td>1.7 - 3.7</td>
<td>1.3 - 2.1</td>
<td>1.1 - 2.2</td>
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<tr>
<td>NBR</td>
<td>2.6 - 4.5</td>
<td>2.4 - 4.1</td>
<td>1.5 - 2.5</td>
<td>1.4 - 2.4</td>
</tr>
<tr>
<td>HNBR</td>
<td>6.8 - 11.3</td>
<td>6.1 - 10.1</td>
<td>3.8 - 6.1</td>
<td>3.7 - 6.1</td>
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<tr>
<td>EPM, EPDM</td>
<td>6.8 - 11.3</td>
<td>6.1 - 10.1</td>
<td>3.8 - 6.3</td>
<td>3.7 - 6.1</td>
</tr>
<tr>
<td>PE</td>
<td>1.5 - 7.6</td>
<td>1.4 - 6.8</td>
<td>0.8 - 4.2</td>
<td>0.8 - 4.0</td>
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<tr>
<td>CM</td>
<td>6.8 - 10.6</td>
<td>6.1 - 9.5</td>
<td>3.8 - 5.9</td>
<td>3.7 - 5.7</td>
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<tr>
<td>EVA</td>
<td>2.6 - 5.3</td>
<td>2.4 - 4.7</td>
<td>1.5 - 3.0</td>
<td>1.4 - 2.9</td>
</tr>
<tr>
<td>Q</td>
<td>1.0 - 2.0</td>
<td>0.4 - 0.8</td>
<td>0.4 - 0.8</td>
<td>0.4 - 0.8</td>
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<tr>
<td>190 Crosslinking*</td>
<td>14.5°C</td>
<td>170°C</td>
<td>175°C</td>
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<td>12 Crosslinking</td>
<td>115°C</td>
<td>130°C</td>
<td>135°C</td>
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</table>

* Very short crosslinking times can be achieved by raising 190-temperatures to approximately 40°C above the mentioned temperature.
Applications

Crosslinked EVA

Ethylene vinyl acetate (EVA) is a class of copolymers. The crosslinking with organic peroxides is carried out in order to improve the elongation, the aging and the heat resistance. Applications are hot melt adhesives, films, electrical cables, solar panels, shoe soles and floor coverings.

Crosslinked EPM/EPDM

Ethylene-propylene copolymer (EPM) is a copolymer of ethylene and propylene. Ethylene-propylene terpolymer (EPDM) is a terpolymer of ethylene, propylene and a diene component. Advantages are more enhanced temperature resistance, lower compression set and a better aging behavior. Applications are hoses, seals, profiles, cables, shoe soles and conveyor belts.

Crosslinked Silicone Rubber

Silicones (poly (organo)siloxanes) is a group of synthetic polymers in which silicon atoms are linked via oxygen atoms. As silicone rubber is referred to the compositions of the poly (organo) siloxanes transferred into a rubber-elastic state.

Crosslinked Polyethylene

Crosslinked polyethylene foam is produced by crosslinking of thermoplastic polyethylene (LDPE, HDPE or DPE) through organic peroxides. Due to the crosslinking the impact resistance, abrasion resistance, low-temperature and stress cracking resistance can significantly be increased.

Crosslinked HDPE & Crosslinked LDPE

Crosslinked Polyethylene (PE-X) is produced by crosslinking of thermoplastic polyethylene (LDPE, DPE or HDPE) through organic peroxides. Due to the crosslinking the impact resistance, abrasion resistance, low-temperature and stress cracking resistance can significantly be increased.

Safe processing- and crosslinking times

Safe processing temperature $t_{2}$

The raw materials (polymer, additives, peroxide) have to be homogenized before the crosslinking reaction can take place. Although the temperature sensitive peroxide will be the last raw material which is added for homogenization, one has to take care to avoid temperatures at which the peroxide decomposes and the crosslinking reaction starts. This maximum processing temperature of the peroxides is called the scorch temperature. The safe processing temperature $t_{2}$ is defined as the temperature, at which the scorch time is longer than 20 minutes.

Typical crosslinking temperature $t_{90}$

The typical crosslinking temperature $t_{90}$ is defined as the temperature at which 90% of the crosslinks in the compound are formed within about 12 minutes.

Storage temperatures

Crosslinking peroxides can be stored and handled without risk providing certain precautions are taken. Please refer to our MSDS and product labels for precise information and keep products at recommended storage temperature.

Cable insulation

Cable insulation from peroxide cross-linked polyethylene (XLPE) are used in 1-380 kV range. Important after crosslinking are good dielectric properties and dimensional stability at higher temperatures. Mostly LDPE is crosslinked with Dialkylperoxides.

NBR & SBR

Butadiene acrylonitrile rubber (NBR) is produced by copolymerization of acrylonitrile (ACN) and 1,3-butadiene. Materials based on this synthetic rubber are suitable because of their good technological properties for many applications. In particular, radial shaft seals, sealing elements for hydraulic and pneumatic systems as well as O-rings.

Styrene butadiene rubber (SBR) is produced by the copolymerization of 1,3-butadiene and styrene. SBR is now the most widely used synthetic rubber and finds its application in the production of tires (tread), gaskets and conveyor belts.

Crosslinked Foamed Polyethylene

Crosslinked polyethylene foam is produced by crosslinking of polyethylene in the presence of foaming agents. Crosslinked PE foam has a fine, regular and closed cell structure with low density. The closed cell structure provides excellent heat and cold insulation properties. In addition, cross-linked PE foam does not absorb water. Applications are noise protection, thermal insulation, seat cushions, gym mats or floats (swimming aids).

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Cable insulation from peroxide cross-linked polyethylene (XLPE) are used in 1-380 kV range. Important after crosslinking are good dielectric properties and dimensional stability at higher temperatures. Mostly LDPE is crosslinked with Dialkylperoxides.

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Crosslinked Silicone Rubber

Silicones (poly (organo)siloxanes) is a group of synthetic polymers in which silicon atoms are linked via oxygen atoms. As silicone rubber is referred to the compositions of the poly (organo) siloxanes transferred into a rubber-elastic state.

Crosslinked Polyethylene

Crosslinked polyethylene foam is produced by crosslinking of polyethylene in the presence of foaming agents. Crosslinked PE foam has a fine, regular and closed cell structure with low density. The closed cell structure provides excellent heat and cold insulation properties. In addition, cross-linked PE foam does not absorb water. Applications are noise protection, thermal insulation, seat cushions, gym mats or floats (swimming aids).
### Di-(2,4-dichlorobenzoyl)-peroxide

**Chemical name** / **CAS number** / **Chemical structure**

Di-(2,4-dichlorobenzoyl)-peroxide / 133-14-2

**Physical form**

Peroxide

**Active oxygen assay**

2,11%

**Standard package**

20kg pail

**Storage temperatures**

max. 47°C, min. 65°C

**Half life temperatures**

10h 80°C, 1h 75°C, 0,1h 90°C

**Processing temperatures**

t2 10h, t90 1h

**Regulatory Recommendations**

FDA 177.2600, BfR XV

**UN-No.**

3106

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### Di-(4-methylbenzoyl)-peroxide

**Chemical name** / **CAS number** / **Chemical structure**

Di-(4-methylbenzoyl)-peroxide / 895-85-2

**Physical form**

Peroxide

**Active oxygen assay**

2,56%

**Standard package**

18kg pail

**Storage temperatures**

max. 70°C, min. 89°C

**Half life temperatures**

130°C 80°C, 110°C 110°C

**Processing temperatures**

t2 70°C, t90 80°C

**Regulatory Recommendations**

FDA 177.2600, BfR XV

**UN-No.**

3106

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### tert-Butyl peroxybenzoate

**Chemical name** / **CAS number** / **Chemical structure**

tert-Butyl peroxybenzoate / 614-45-9

**Physical form**

Liquid

**Active oxygen assay**

8,07%

**Standard package**

25kg container

**Storage temperatures**

max. 87°C, min. 110°C

**Half life temperatures**

136°C 100°C, 140°C 140°C

**Processing temperatures**

t2 80°C, t90 110°C

**Regulatory Recommendations**

FDA XLVI, BfR 3103, UN-No. 3106

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### 1,1-Di-(tert-butylperoxy)-3,3,5-trimethylcyclohexane

**Chemical name** / **CAS number** / **Chemical structure**

1,1-Di-(tert-butylperoxy)-3,3,5-trimethylcyclohexane / 6731-36-8

**Physical form**

Powder with chalk

**Active oxygen assay**

4,23%

**Standard package**

25kg cardboard box

**Storage temperatures**

max. 91°C, min. 117°C

**Half life temperatures**

138°C 115°C, 145°C 145°C

**Processing temperatures**

t2 115°C, t90 130°C

**Regulatory Recommendations**

FDA XLVI, BfR 3100

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### Dicumyl peroxide

**Chemical name** / **CAS number** / **Chemical structure**

Dicumyl peroxide / 80-43-3

**Physical form**

Fine granules, Powder, Paste in silicone oil, Powder with clay, Powder with chalk

**Active oxygen assay**

5,80%

**Standard package**

20kg cardboard box, 20kg cardboard box, 20kg cardboard box, 20kg cardboard box, 20kg cardboard box

**Storage temperatures**

max. 112°C, min. 138°C

**Half life temperatures**

162°C 130°C, 170°C 170°C

**Processing temperatures**

t2 130°C, t90 170°C

**Regulatory Recommendations**

FDA 177.2600, BfR XXXX, UN-No. 3100

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### PEROXAN BD-Paste 50 Sl

**Chemical name** / **CAS number** / **Chemical structure**

Peroxide / 133-14-2

**Physical form**

Paste in silicone oil

**Active oxygen assay**

50%

**Standard package**

2,11%

**Storage temperatures**

max. 47°C, min. 65°C

**Half life temperatures**

10h 80°C, 1h 75°C, 0,1h 90°C

**Processing temperatures**

t2 10h, t90 1h

**Regulatory Recommendations**

FDA 177.2600, BfR XV

**UN-No.**

3106
<table>
<thead>
<tr>
<th>Trade name</th>
<th>Chemical name / Chemical structure</th>
<th>CAS number / Physical form</th>
<th>Peroxide assay</th>
<th>Active oxygen assay</th>
<th>Standard package</th>
<th>Storage temperatures</th>
<th>Half life temperatures</th>
<th>Processing temperatures</th>
<th>Regulatory Recommendations</th>
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<tbody>
<tr>
<td>Di-(2-tert-butyl-peroxyisopropyl) benzene</td>
<td>25155-25-3</td>
<td>Powder with clay</td>
<td>97%</td>
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<td>14°C</td>
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<td>Powder with clay</td>
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<td>PEROXAN BU</td>
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<td>78-63-7</td>
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