Homogenizing Agents

Homogenizing agents are products which improve the homogeneity of difficult to blend elastomers, they also assist the incorporation of other compounding materials (Figure 31). Intra-batch and batch to batch viscosity variation is reduced by their use.

They are resin based mixtures which exhibit a good compatibility with various elastomers and facilitate blending through early softening and wetting the polymer interfaces. Since the softening resins exhibit a certain tackiness polymers which tend to crumble and polymer blends will coalesce more easily, energy input is maintained at a high level, i.e., mixing is more effective and mixing times can often be reduced.

Due to the excellent wetting properties of the homogenizing agents fillers are incorporated at a faster rate and are more evenly distributed. Filler agglomerates can frequently be avoided.

Apart from their compacting effects the homogenisers lead to enhanced green strength when used as a partial replacement for processing oil and compound flow is facilitated through improved homogeneity and a certain softening effect. They increase green tack of many compounds and boost the efficiency of tackifying agents.

The homogenizing agents promote

- Blending of elastomers
- Batch to batch uniformity
- Filler incorporation and dispersion
- Shortening of mixing cycles
- Energy savings
- Building tack
The greater the difference in solubility parameter and/or viscosity of each component elastomer in a blend, the more difficult it is to produce a homogeneous mix (Figure 32). Blends of plasticizers, each compatible with different elastomers, can in theory be effective at improving blend homogeneity, provided they have a viscosity sufficiently high to maintain high shear on mixing. Plasticizers have the disadvantage of being prone to migration and bloom. Therefore mixtures of higher molecular weight products, i.e., resins are more often used.

<table>
<thead>
<tr>
<th>Elastomer</th>
<th>Plasticizer</th>
<th>Homogenizing Agent</th>
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</thead>
<tbody>
<tr>
<td>AU, EU</td>
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<tr>
<td>NBR (high ACN)</td>
<td>Polar ethers</td>
<td>STRUKTOL 40 MS Homogenizer</td>
</tr>
<tr>
<td></td>
<td>Highly polar esters</td>
<td></td>
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<tr>
<td>NBR (med ACN)</td>
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<td></td>
</tr>
<tr>
<td>NBR (low ACN)</td>
<td>Low polar esters</td>
<td>STRUKTOL 60 NS Homogenizer</td>
</tr>
<tr>
<td>CR</td>
<td>Aromatic</td>
<td></td>
</tr>
<tr>
<td>SBR</td>
<td>Naphthenic</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BR</td>
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<td></td>
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<tr>
<td>IIR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPDM</td>
<td>Paraffinic</td>
<td></td>
</tr>
<tr>
<td>9.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.0</td>
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The homogenizing resins are themselves complex blends and contain parts that are compatible with aliphatic and aromatic structures in a blend.
<table>
<thead>
<tr>
<th>RESIN</th>
<th>APPLICATION</th>
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</thead>
<tbody>
<tr>
<td>Coumarone resins</td>
<td>Filler incorporation</td>
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<tr>
<td></td>
<td>Tackifier</td>
</tr>
<tr>
<td>Petroleum resins</td>
<td>Viscosity reduction</td>
</tr>
<tr>
<td></td>
<td>Filler incorporation</td>
</tr>
<tr>
<td></td>
<td>Tackifier</td>
</tr>
<tr>
<td>Reinforcement polymers</td>
<td>High hardness</td>
</tr>
<tr>
<td>Asphalt, bitumen, tar</td>
<td>Filler incorporation</td>
</tr>
<tr>
<td></td>
<td>Viscosity reduction</td>
</tr>
<tr>
<td></td>
<td>Tackifier</td>
</tr>
<tr>
<td>Lignin</td>
<td>Reinforcement</td>
</tr>
<tr>
<td></td>
<td>Filler incorporation</td>
</tr>
<tr>
<td>Rosins</td>
<td>Emulsifier</td>
</tr>
<tr>
<td></td>
<td>Tackifier</td>
</tr>
<tr>
<td>Phenol formaldehyde resins</td>
<td>Tackifier</td>
</tr>
<tr>
<td></td>
<td>Reinforcing resin</td>
</tr>
<tr>
<td></td>
<td>Curing resin</td>
</tr>
</tbody>
</table>

Resinous compounding materials and potential raw materials for use as homogenizing resins (Figure 33) can be divided into:

**Hydrocarbon resins** including coumarone-indene resins, petroleum resins, terpene resins, bitumens, tar and copolymers, e.g., high styrene reinforcement polymers and **Rosins**, their salts, esters and other derivatives,

**Phenolic resins** of various kinds like alkylphenol/formaldehyde resins, alkylphenol and acetylene condensation products, lignin and modifications thereof to name a few.
**Coumarone resins**, produced from coal-tar, were the first synthetic resins used as processing additives because of their ability to act as dispersing agents improving filler incorporation and as tackifiers. They are typical aromatic polymers mainly consisting of polyindene. The structural elements of these copolymers are (Figure 34) methylnidene, coumarone, methylcoumarone, styrene and methylstyrene. The melting range of these products is between 35 and 170 °C.

**Petroleum resins** are relatively inexpensive products often used at fairly high dosages, up to 10 phr and above. They are polymers produced from the C5 cut of highly cracked mineral oils. The petroleum resins are relatively saturated and also available with a high content of aromatic structures. Grades with a lower content of aromatic compounds have a stronger plasticizing effect. The highly saturated grades are used by the paint industry. Apart from cyclopentadiene, dicyclopentadiene and its methyl derivatives, styrene, methylstyrene, indene, methylnidene and higher homologues of isoprene and piperylene are found in these resins.

This may explain their high compatibility with different elastomers.

**Copolymers** like high styrene resin masterbatches are used for high hardness compounds. While straight polystyrene can hardly be processed in rubber compounds, copolymers from styrene and butadiene with higher styrene contents have proven their worth.

Polyoctenamer (Vestenamer), produced through a metathesis reaction from cyclooctene, is another useful polymer for high hardness vulcanizates. Due to its thermoplastic character it is an easy to process, cross-linkable elastomer which has gained importance.
It has been used where green strength and dimensional stability of extrudates are of importance, the high crystallinity of Vestenamer imparts good rigidity below the Tg. when molten, Vestenamer has a low viscosity and can contribute towards flow characteristics of the compound.

Terpene resins are very compatible with rubber and yield high tackiness. However, they are mainly used for adhesives. The polymers are based on α- and β- pinene. The cyclobutane ring is opened during polymerization and polyalkylated compounds are formed (Figure 35). Terpene resins improve ageing performance and resistance against oxidation of rubbers.

Asphalt and bitumen are products used since the very beginning of rubber processing. Their tackifying effect is not very distinct. They are relatively inexpensive products. While asphalt is a naturally occurring product, bitumen is produced from the residues of the mineral oil production. Blown bitumen, oxidized in order to achieve higher solidification points, is also known as mineral rubber and is a good processing additive, for example, in difficult to process compounds having a high percentage of polybutadiene. Mineral rubber is also successfully used to improve the collapse resistance of extrusions.
Rosins are natural products obtained from the pine tree. They are mixtures of organic substances, for the most part doubly unsaturated acids, such as abietic acid, pimaric acid and their derivatives (Figure 36). In order to reduce the sensitivity to oxidation resins are partially hydrogenated or disproportionated. Their acidity has a slight retarding effect. Abrasion resistance, in particular that of SBR, is said to be improved. Rosin acid is widely used (as a salt) in the production of synthetic rubbers (SBR) because of its emulsifying properties.

*Figure 36*
**Phenolic resins** (Figure 37) are mainly used as tackifiers, reinforcing resins, curing resins and in adhesives.

**Lignin** has a complex structure and is based on various substituted phenols which are in part linked via aliphatic hydrocarbon units. As a by-product of the cellulose industry and especially the paper industry it is available in large quantities and is good value. It was often used in particular for shoe soling where it improved incorporation and dispersion of high mineral filler loadings.

![Alkylphenol Tackifiers Synthesis (simplified)](image)

Modern homogenizing agents are blends of rubber compatible non-hardening synthetic resins of different polarities. With their specific composition they promote the homogenisation of elastomers differing in molecular weight, viscosity and polarity. They are also valuable tools for homopolymer compounds.

As an example, the use of a well-known homogenizing agent, STRUKTOL 40 MS FLAKES, in butyl compounds which are known to be difficult to process should be mentioned. Filler dispersion, splice adhesion, physical properties and impermeability are significantly improved through the use of this resin.
**Processing with Homogenizing Agents**
The homogenizing agents are usually added at the beginning of the mixing cycle, particularly when elastomer blends are used. They exhibit optimum effectiveness around their softening temperature. The recommended dosage is between 4 and 5 phr. Difficult to blend elastomers will require an addition of 7 to 10 phr.

**Struktol Products and their Use**

**STRUKTOL® 40 MS FLAKES** is a mixture of dark, aromatic hydrocarbon resin which has a very good compatibility with most standard elastomers, such as SBR, NR, NBR, CR, IIR, BIIR, EPDM and BR and is used in elastomer blends and homopolymer compounds. Blending of elastomers with different polarities and/or viscosities are significantly facilitated. In particular difficult to process tire tube and innerliner compounds have been significantly improved with STRUKTOL 40 MS FLAKES.

**STRUKTOL 60 NS FLAKES** is a mixture of light-colored aliphatic hydrocarbon resin. It is designed for light-colored compounds where non-staining is specified. Its action is comparable with that of STRUKTOL 40 MS FLAKES. This product has proven its value, particularly in compounds based on NBR/EPDM blends.

**STRUKTOL TH 10 A** is a mixture of aliphatic and aromatic resins. It is a processing additive that gives good tack and homogeneity in row compounds. Due to the balanced combination of the tackifying resins and homogenizing agent, an optimum dispersion of the ingredients in the raw compound is achieved which maintains its greet tack for several weeks under normal storage conditions.

**STRUKTOL® TH 64** is a mixture of low molecular weight resins. It can be used as a tackifier for natural and synthetic elastomers for improving long-term building tack.

**STRUKTOL® STRUKREZ 110** is a polymeric resin blend. Blending of elastomers with different polarities or viscosities are significantly facilitated.

**STRUKTOL® STRUKREZ 220** is a molecular assembled resin designed for unique qualities in polymer processing. Green tack is improved with STRUKREZ 220.