Silicone Containing Additives

1. Polydimethylsiloxane

Polydimethylsiloxane, shortly called silicones, are very versatile raw materials which can exhibit a variety of properties dependent on their molecular structure. Silicones are used in paint additives for example as:

- defoamers and deaerators
- slip and levelling additives
- wetting and dispersing additives
- hammer finish additives

The principal reasons for the wide spectrum of uses of silicones as components in the production of paint additives are:

- low surface tension
- excellent lubricating
- slip properties

The surface tension of silicones is around 20 mN/m, which means that silicones quickly form a film at interfaces, when introduced into a liquid.

Differently structured silicones form films at the interface between substrate and coating and promote wetting of the substrate. Similarly specially selected silicones move to the air/liquid paint interface where they destabilise the air bubbles and cause them to burst. After application of coating systems this film is formed on the surface and produces a slip effect.

The possible application of silicones depends very much on their molecular structure and molecular mass. The basic building brick of all silicones is polydimethylsiloxane which has the following molecular structure:

\[
\begin{array}{c}
\text{CH}_3 \\
\text{Si-O} \\
\text{Si-O} \\
\text{Si-(CH}_3)_3 \\
\end{array}
\]

The following table presents a summary of these relationships displayed by polydimethylsiloxane:

<table>
<thead>
<tr>
<th>Typ</th>
<th>Molecular Mass</th>
<th>Typical application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>~ 3,000</td>
<td>anti-floatation</td>
</tr>
<tr>
<td>2</td>
<td>~ 5,000</td>
<td>wetting additive</td>
</tr>
<tr>
<td>3</td>
<td>~ 10,000</td>
<td>levelling additive</td>
</tr>
<tr>
<td>4</td>
<td>~ 20,000</td>
<td>slip additive</td>
</tr>
<tr>
<td>5</td>
<td>~ 50,000</td>
<td>deaeration / defoaming</td>
</tr>
<tr>
<td>6</td>
<td>~ 200,000</td>
<td>hammer finish</td>
</tr>
</tbody>
</table>

Polydimethylsiloxanes distinguish themselves only by the length of the polymer chains (i.e. magnitude of "x"). The average molecular mass (or the viscosity) is a measure of the length of the polymer chain (i.e. degree of polymerisation). The properties of these silicones with a simple structure depend therefore solely on the molecular mass.
Product examples of polydimethylsiloxane

**ANTIGEL®**
It contains apart from other components a small quantity of low molecular weight silicones like type 1. It has therefore, among others, the properties of an anti-floatation additive.

**SCHWEGO® mar 8300, SCHWEGO® mar 8301, SCHWEGO® mar 8310, SCHWEGO® mar 8311**
These products contain, among other components, type 4 silicones and act therefore as slip additives.

2. Modified polydimethylsiloxane

By chemical modifications of the molecular structure of polydimethylsiloxane, modified silicones with new properties are obtained. A schematic chemical formulation of such modified silicones is shown in the following illustration:

The organic modification can represent any desired molecular grouping with exception of the alkyl group (-CH₃).

The properties of these silicone products depend on three factors:
- type of organic modification
- relation of the x- and y-units
- molecular mass

Product examples of modified polydimethylsiloxane

**Phenyl modified silicones**
This silicone modification (C₆H₅) produces a different set of properties when compared with polydimethylsiloxane.

The main properties of phenyl modified silicones are higher temperature resistance, better lubricating, and solubility properties. Phenyl modified silicones are very good in promoting flow. This property is exploited in **SCHWEGO® foam 6388** and **BLISTER FREE 88**.

**SCHWEGO® foam 6388** and **BLISTER FREE 88** are used as defoaming and deaerating additives of unsaturated polyester systems. **SCHWEGO® foam 6388** and **BLISTER FREE 88** also contain a small quantity of a phenyl modified silicone, which explains the flow promoting action.
3. Silicone copolymers

Silicone copolymers are compounds, which combine the properties of silicones with those of the corresponding copolymer. This combination creates products with new interesting properties. They minimise the risks incurred by accidental excessive dosage of “normal” silicone oils as

- cratering
- poor adhesion
- recoating problems
- incompatibility in systems

Polyethers or polyesters are frequently used as copolymer component. The schematic chemical structure of silicone copolymers is:

\[
\begin{array}{c}
\text{EO: Ethylene oxide units} \\
\text{PO: Propylene oxide units}
\end{array}
\]

Planned chemical synthesis can produce the exactly desired properties of silicone copolymers. The m-unit is the hydrophilic organic component, the n-unit the hydrophobic organic component and the p-unit contributes the typical property characteristics of the silicone copolymer. The m-n-p-mass ratio therefore determines the overall properties of the silicone copolymer.

Schwegmann additives on silicone copolymer base:

**SCHWEGO® wett 6237**
This product contains among others a silicone copolymer consisting of polyether units, a relatively small molecular mass and a large EO/PO mass ratio. Therefore it is highly polar. Apart from this it has low surface tension. **SCHWEGO® wett 6237** is formulated to cover the substrate/coating film interface thus promoting the wetting of the substrate.

**SCHWEGO® flow 8057, SCHWEGO® flow 8058**
These products also contain silicone-polyether copolymers. The EO/PO mass ratio is larger and the molecular mass is higher. This copolymer causes even higher polarity. **SCHWEGO® flow 8057** and **SCHWEGO® flow 8058** have the tendency to prefer the interface paint film/air thus “calming” the paint surface and promoting flow.

**SCHWEGO® mar 8304, SCHWEGO® mar 8305**
These products also contain silicone-polyether-copolymers but with a medium EO/PO mass ratio and a rather high molecular mass. The silicone unit forms a high proportion. **SCHWEGO® mar 8304** and **SCHWEGO® mar 8305** show quite high incompatibility in the system and therefore possess a strong tendency to move to the paint film/air interface. Hence, slip and mar resistance are improved.