Defoaming / Deaerating

The growing requirements at the paint developer to optimize his formulation in environmental (reduction of organic solvents, free of VOC, free of APEO, based on native raw materials …) and also in economical view is the starting point for the raw materials supplier to find new solutions with the goal to fulfill this new requirements.

So it was also necessary to develop new products in the field of defoamers. Reasons were that sometimes the old products did not fulfill the new environmental demands or the efficiency was not good enough in the new kind of resins and emulsions. The choice of the right defoamer is very important and offers advantages in the production of the paint, at the application and in the optic of the dry paint film. So it is possible to improve with the right defoamer the expensive grinding process, to avoid troubles at the filling of the paint and to prevent surface defects like pinholes or crater in the dry paint film.

What is foam? How to get foam?

By the current state of view, foam is a thermodynamic unstable two-phases-system of rough distributed gaseous in liquid or solid medium.

Pure liquid do not foam. During shaking of pure water bubbles occur (sphere foam) inside of the liquid, the bubbles rise at the surface of the liquid and break (fig.1).

fig.1

If there is a stabilization of the bubbles at the surface of the liquid, the sphere foam deformed above the boarder of the densely sphere packing to polyheydral foam (fig.3).

The speed of the bubble to achieve the surface of the liquid is dependent on the viscosity and the diameter of the bubble. They obey the law of stokes.

As per description foam is in pure liquid thermodynamic unstable. This statement is in contrast of the daily practice in the paint world. Normally paints are not pure liquids. Surface active substances are inside to achieve special properties.
So it is necessary to use emulsifier for the production of the polymer emulsion. Additives like dispersing agents, substrate wetting agents or leveling agents are in use to achieve special paint properties or to improve the process at the production.

Surface active substances like emulsifiers are dipoles with hydrophobic and hydrophilic centers. In nonionic types the polyether could be the ethylene oxide with different molecule length the hydrophilic part and the hydrophobic counter pole a fatty alcohol or a fatty acid.

These products are able to concentrate at the interface liquid / air or to build micelles in water in doing the orientation of the hydrophilic part (under reduction of the surface tension) in direction water and the hydrophobic part in direction air. This means, if you get air in a liquid with surface active substances, the orientation of the surfactant will be at the interface liquid / air at the surface of the liquid and at the bubble (fig.2)). If these bubbles reach the surface, which also coated with surfactant, a surfactant-stabilized double layer is formed.

Initiator for foam troubles in the paint industry could be following parameters:

- production: grinding- and mixing process; filling of the paint
- application: spraying (airless), curtain coating, brushing, rolling
- chemical reaction: two pack coating systems
- substrate: wood
- paint parameter: viscosity, rheology profile

The coating industry is always looking for solutions to prevent micro foam or macro foam. Normally micro foam is more a problem in solvent-based or solvent-free systems, but also in aqueous formulations with low PVC. Macro foam is more usual in aqueous systems. The goal of defoamers and deaerators is to prevent this kind of foam, whereat defoamer act more against the foam at the surface of the liquid (macro foam) and deaerator speed up the bubble (micro foam) in the wet film, so that the bubble can leave the film before drying. But in the praxis it is very often not possible to differentiate clearly between defoamers or deaerators.
- macro foam exist primarily on polyhedral foam

- micro foam are bubbles, which were not able to rise to the surface but remain in the liquid phase.

**Effectiveness from defoamers**

The defoamer must be insoluble in the formulation to be defoamed. It must penetrate very quickly to the foam lamella, must spread on this and must destroy this. In the market it is normal to classify the different types in mineral-, white-, silicone oil or polymer defoamers. These are the carriers, with the task to transport the active substance as quickly as possible to the foam lamella (entering coefficient) and to spread (spreading coefficient) on this. The active substances such as silica absorb the surfactants from the foam lamella to get a destabilization and in ideal case a destroying of this. Carriers without active substances have also an antifoam effect, but very often not good enough to fulfill the requirements from the paint industry.

**Examples from carriers**

- mineral oil
- silicone oil
- white oil
- polymere
- natives oil

**Examples from active substance**

- silica
- wax
- urea
- metal soap

The properties of above mentioned classes of products can be roughly abstract in following table:

<table>
<thead>
<tr>
<th></th>
<th>mineral oil</th>
<th>white oil</th>
<th>native oil</th>
<th>silicone oil</th>
<th>polymere</th>
<th>defoamer emulsion</th>
</tr>
</thead>
<tbody>
<tr>
<td>efficiency</td>
<td>good</td>
<td>very good</td>
<td></td>
<td>very good</td>
<td></td>
<td>good</td>
</tr>
<tr>
<td>long term stability</td>
<td>good</td>
<td>good</td>
<td></td>
<td>good</td>
<td>moderate</td>
<td></td>
</tr>
<tr>
<td>incorporation</td>
<td>good – moderate</td>
<td>moderate – good</td>
<td>good</td>
<td>very good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gloss / haze</td>
<td>moderate</td>
<td>good – moderate</td>
<td>good</td>
<td>depend from the type</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As per description defoamers should be insoluble in the system in which they should work. But also the incorporation should be possible with low shear performance and without influence on the leveling (crater), gloss or haze in the different kind of coatings. Furthermore efficiency should be not less after long storage of the paint.

Schwegmann has a wide range of defoamers / deaerators for solvent-based, solvent-free and aqueous formulations. They are based on mineral oils, natives oils, modified silicone oils and polymers.

With the goal to reduce the VOC content the first step was the introduction of our VOC free/poor defoamers SCHWEGO® foam 6354, 6375, 6377 und 6388. These are further developments our BLISTER free – products. It was possible to reduce the VOC content and also to improve the efficiency. See here the test results in long oil alkyd resin (fig.4) and acrylic resin, OH- functional (fig.5).

SCHWEGO® foam 6305 is a new emulsion defoamer developed especially for aqueous coatings. SCHWEGO® foam 6305 prevents micro foam and macro foam. The application fields are high gloss paints, matt to satin-gloss emulsion paints, clear coats, wood - and industrial coatings.

SCHWEGO® foam 6360 is a deaerator special for UV – coatings. These product is able to crosslink at the UV drying process and do not disturb the film.

SCHWEGO® eco foam 6325, SCHWEGO® eco foam 6326, SCHWEGO® eco foam 8336 and SCHWEGO® eco foam 8338 are based on renewable raw materials and regarding the ASTM-D 6886 bio-based products and so first recommendation for water–based green paints. SCHWEGO® eco foam 6320 and SCHWEGO® eco foam 6321 are special products for non-aqueous bio-formulations.

Test methods for judgement of defoamers:

Density test
The complete formulation (with/without defoamer) is stirred with a dissolver under defined parameters (time, rotation speed …). After the stirring step measure directly the density with a density bottle. Best efficiency is the product with the highest density.

Compatibility test
The paint is applied with a doctor blade (defined thickness) on glass. After the drying of the paint measure the influence of the defoamer on gloss, haze and leveling (crater, fish eyes).

Volume test
Air is supplied in the system by stirring or shaking under defined conditions. Thus the resulting total volume is determined. Furthermore the time-dependent foam reduction is observed.

Coating test (Roller test)
The paint (defined amount) is applied with a sponge roller to a substrate. Micro- and macro foam can be evaluated on the dried paint film.

Long term efficiency
Store the paint 21 days at 50°C (or 40°C, depending from the emulsion) and repeat the density test and coating test. The test results should be equal to the first (directly) results. If not, the dosage of the defoamer is too low in this system.

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Tel.: +49 (0) 2225 9226-0 · Fax +49 (0) 2225 9226-33 · E-Mail: info@SchwegmannNet.de · www.SchwegmannNet.de
Test results our defoamers in different systems

The results are demonstrated in volume % air, means we calculated the amount of air, which we got after a defined stirring time. Best efficiency is the defoamer with the lowest content of volume % air.

test results in a long oil alkyd resin

resin: Setal AF 681 (Nuplex Industries Ltd.)
dosage: 0.5% defoamer / resin
test method: 10 minutes stirring at 4000 rpm

fig.4

![Chart showing air content comparison](chart1.png)

BF = BLISTER FREE, SF = SCHWEGO® foam

Test results in an acrylic resin, OH – functional

resin: Setalux 1151 XX-51 (Nuplex Industries Ltd.)
dosage: 0.5% defoamer / resin
test method: 10 minutes stirring at 4000 rpm

fig.5

![Chart showing air content comparison](chart2.png)

BF = BLISTER FREE, SF = SCHWEGO® foam
test results in a high gloss emulsion paint based on an acrylic emulsion, self-crosslinking

dispersion: Neocryl XK 98 (DSM N.V.)
dosage: 0.5% defoamer / paint
test method: 5 minutes stirring at 4000 rpm

fig.6

<table>
<thead>
<tr>
<th>Air content [%]</th>
<th>without</th>
<th>SF 6305</th>
<th>SeF 6325</th>
<th>SF 8333</th>
<th>SeF 8336</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>22.6</td>
<td>5.2</td>
<td>8.5</td>
<td>5.9</td>
<td>10.6</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SF = SCHWEGO® foam, SeF = SCHWEGO® eco foam

test method: coating test with the sponge roller

fig.7

<table>
<thead>
<tr>
<th>1 = bad</th>
<th>2 = medium</th>
<th>3 = good</th>
<th>4 = very good</th>
<th>5 = excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF 6305</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SeF 6325</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>SF 8333</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>SeF 8336</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

SF = SCHWEGO® foam, SeF = SCHWEGO® eco foam

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test results in two satin-gloss paints based on a styrene / acrylic dispersion and a vinylacetate / vinylversatate dispersion (MFFT of both: 2°C)

dosage: 0.5% defoamer / paint
test method: 5 minutes stirring at 4000 rpm

fig. 8

![Graph showing air content of different paints](image)

 SF = SCHWEGO® foam, SeF = SCHWEGO® eco foam

test method: coating test with the sponge roller in a satin-gloss paint (styrene / acrylic – dispersion)

fig.9

![Graph showing coating test results](image)

 SF = SCHWEGO® foam, SeF = SCHWEGO® eco foam
test method: coating test with a sponge roller (vinylacetate / vinylversatate – dispersion)

fig. 10

![Bar chart](image)

SF = SCHWEGO® foam, SeF = SCHWEGO® eco foam

test results in an aqueous wood primer based on a cationic alkyd emulsion

emulsion: Necowell 4400 (ASK Chemicals)
dosage: 0.5% defoamer / paint
test method: 5 minutes stirring at 4000 rpm

fig. 11

![Bar chart](image)

SF = SCHWEGO® foam, SeF = SCHWEGO® eco foam

It is not possible to find one product in the market with real good efficiency in all different kind of formulations. Reason is the complexity of the different paint formulations. It is always the best to find the right defoamer for the formulation with determined work.
Summary our test results:

The VOC free / poor defoamer SCHWEGO® foam 6354 / 6375 / 6377 und 6388 are slightly better in the density test compared with the standard products. SCHWEGO® foam 6375 achieve in both resins very good efficiency against macro foam, but also in coating test. The deaeration effect is very quick.

Application fields of SCHWEGO® foam 6375 are high-solid-house paints, NC-lacquer, furniture coatings.

SCHWEGO® foam 6305 is a polymer type for aqueous formulations. It has universal properties and prevents micro- and macro foam in different kind of formulations. Application fields are high gloss paints based on pure acrylic dispersion or alkyd emulsions, but also in solvent-free satin-gloss emulsion paints, wood- and industrial coatings.

SCHWEGO® eco foam 6325 is based on native raw materials. Application areas are paints with medium to high PVC and bio-paints. SCHWEGO® eco foam 6325 has no negative influence on the gloss properties of the paint.

SCHWEGO® foam 8325 is a mineral oil type with his application field.

SCHWEGO® foam 8333 is a polymer type. Using areas are high gloss paints, wood coatings, industrial coatings, aqueous 2 pack polyurethane systems and parquet floorings. Furthermore in emulsion paints free of VOC.

SCHWEGO eco foam® 8336 is a silicone oil defoamer for wood coatings, stains, parquet floorings, printing inks, industrial coatings, UV coatings.

Further information from our defoamer:

<table>
<thead>
<tr>
<th>Product</th>
<th>Free of silicone oil</th>
<th>VOC ISO 11890-1 [%]</th>
<th>Solvent-based systems</th>
<th>Aqueous systems</th>
<th>Solvent-free systems</th>
<th>UV - Systems</th>
<th>Bio-Paints</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blister Free 3</td>
<td>○</td>
<td>26.1</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Blister Free 45</td>
<td>○</td>
<td>67.7</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Blister Free 55</td>
<td>○</td>
<td>76.0</td>
<td>X</td>
<td>XX</td>
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<td></td>
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</tr>
<tr>
<td>Blister Free 66</td>
<td></td>
<td>84.5</td>
<td>XX</td>
<td>XX</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Blister Free 75</td>
<td>○</td>
<td>76.0</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blister Free 77</td>
<td>○</td>
<td>90.0</td>
<td>XX</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blister Free 88</td>
<td></td>
<td>95.0</td>
<td>XX</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® foam 6305</td>
<td>&lt; 0.1</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Universal, prevents micro- and macro foam, no influence on the gloss</td>
</tr>
<tr>
<td>SCHWEGO® eco foam 6320</td>
<td>0</td>
<td>XX</td>
<td>XX</td>
<td>X</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® eco foam 6321</td>
<td>0</td>
<td>XX</td>
<td>XX</td>
<td>X</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® eco foam 6325</td>
<td>○</td>
<td>&lt; 0.1</td>
<td>XX</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Product</th>
<th>Free of silicone oil</th>
<th>VOC ISO 11890-1 [%]</th>
<th>Solvent-based systems</th>
<th>Aqueous systems</th>
<th>Solvent-free systems</th>
<th>UV - Systems</th>
<th>Bio-Paints</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCHWEGO® foam 6326</td>
<td>o</td>
<td>&lt; 0.1</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td></td>
<td>Emulsion, carrier: natives oil, easy incorporation, paints, plaster</td>
</tr>
<tr>
<td>SCHWEGO® foam 6331</td>
<td>o</td>
<td>90.0</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SCHWEGO® foam 6345</td>
<td>o</td>
<td>50.5</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>Industrial coatings, improve the leveling</td>
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<tr>
<td>SCHWEGO® foam 6351</td>
<td>o</td>
<td>90.0</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Very good efficiency, leveling additives</td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® foam 6354</td>
<td>o</td>
<td>0</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Very good efficiency to prevent macro foam, 2 pack pur coatings</td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® foam 6360</td>
<td>o</td>
<td>0</td>
<td>XX</td>
<td>XX</td>
<td></td>
<td></td>
<td>Solvent-free systems, UV – coatings, no haze</td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® foam 6375</td>
<td>o</td>
<td>6.0</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Long oil alkyds, printing inks</td>
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<tr>
<td>SCHWEGO® foam 6377</td>
<td>o</td>
<td>0</td>
<td>XX</td>
<td>X</td>
<td>XX</td>
<td></td>
<td>UPE – systems, highly compatible, FDA – approval</td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® foam 6388</td>
<td>1.6</td>
<td></td>
<td>XX</td>
<td>X</td>
<td>XX</td>
<td></td>
<td>UPE – systems, highly compatible</td>
<td></td>
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<tr>
<td>SCHWEGO® foam 8325</td>
<td>0</td>
<td>&lt; 0.1</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td>Emulsion paints, plasters, silica formulations</td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® foam 8333</td>
<td>o</td>
<td>0.6</td>
<td>XX</td>
<td>X</td>
<td>X</td>
<td></td>
<td>Aqueous 2pack polyurethane paints, parquet floorings, high gloss paints, stains, clear coatings</td>
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<tr>
<td>SCHWEGO® foam 8336</td>
<td>0.5</td>
<td></td>
<td>XX</td>
<td>X</td>
<td>XX</td>
<td>XX</td>
<td>Bio-based product Clear coatings, parquet floorings, high gloss paints, UV-systems, printing inks, FDA – approval</td>
<td></td>
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<tr>
<td>SCHWEGO® foam 8338</td>
<td>o</td>
<td>&lt; 0.1</td>
<td>XX</td>
<td></td>
<td></td>
<td>XX</td>
<td>Bio-based product emulsion paints, plasters</td>
<td></td>
</tr>
<tr>
<td>SCHWEGO® foam 8339</td>
<td>0</td>
<td></td>
<td>XX</td>
<td>X</td>
<td>XX</td>
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<td>UV paints, clear coatings, high gloss paints, parquet floorings</td>
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<tr>
<td>Mittel S</td>
<td>98.0</td>
<td></td>
<td>XX</td>
<td>X</td>
<td></td>
<td>X</td>
<td>Stoving paints, 2pack – formulations, printing inks, NC paints, deco-coatings, floor coatings based on epoxy, FDA – approval, biodegradable</td>
<td></td>
</tr>
</tbody>
</table>

XX – especially recommend, X – recommend