UNIQ CHEM

WETTING AND FLOW AGENTS PRODUCT GUIDE

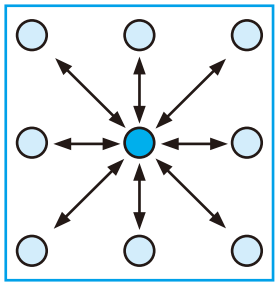
Wetting

The wetting process is a central feature of paint production.

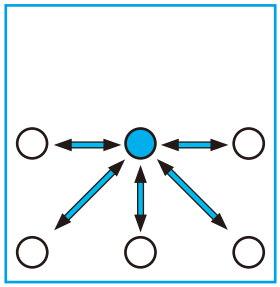
Surface Tension

The main factor in the wetting process is the surface tension of the various components. In order to understand the origin of the surface tension of a given material, for example a liquid, we have to examine the surface of that material on a molecular basis.

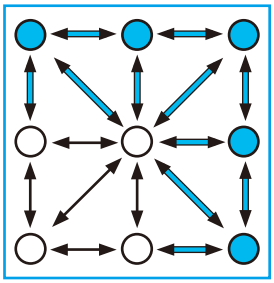
Several attractive forces may exist between single molecules: London, Van der Waals, dipoles, hydrogen-bridges and ionic forces.



In the bulk of the material every molecule is equally surrounded by other molecules leading to equilibrium of forces.



At the surface however, part of the surrounding is missing and therefore all forces are directed into the center of molecules.

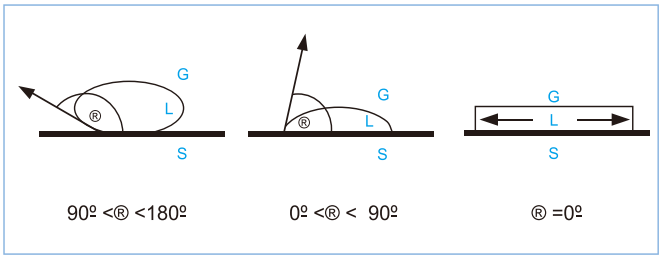


It is even stronger at corners and edges due to less sur- rounding layers being present.

Wetting Processes

The surface tension of a liquid or a solid can be measured by determining the contact angle. The most practical way to calculate it is by the Patton's equation which takes into account the approximation of the solid's surface tension (critical surface tension).

Successful wetting can be directly related to the size of the contact angle.



At a contact angle > 90º no wetting takes place and the droplet keeps its spherical shape.

At a contact angel < 90º wetting improves and the contact surface (droplet-solids interface) increases.

At a contact angle = 0º the desired spreading is achieved.

This is only possible when the surface tension of the liquid is lower than the surface tension of the solid.

That means in the coating industry, that only the liquid can be influenced, as the solids such as pigments and fillers, and also the substrate, have a fixed surface tension.

One example of reducing the surface tension of a liquid is the addition of a surfactant. Accumulation at the surface leads to compensation of tension by interaction of the polar groups. The value obtained for the surface tension is determined by the lower surface tension of the surfactant.

This concept is the basis for solving many problems associated with coatings, such as pigment wetting, and surface defects such as craters, poor flow and foam.

Surface Control

Surface control additives are used to prevent surface defects during paint application and improve resistance and appearance of the dry film.

Surface Defects

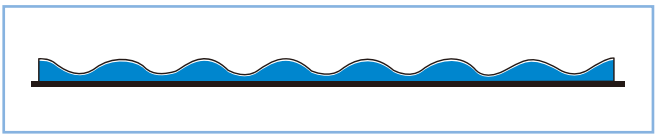
Possible surface defects during paint application are:

- Orange Peel
- Pinholes
- Craters
- Fish Eyes
- Edge Crawling
- Air-draft Sensitivity
- Telegraphing
- Floating (Bénard cells)
- Silking

Orange Peel:

This typical appearance of the surface is only observed following spray applications. Three main factors influence this defect:

- Viscosity of the sprayed liquid
- Spraying conditions such as pressure, air/liquid ratio
- Surface tension of the liquid

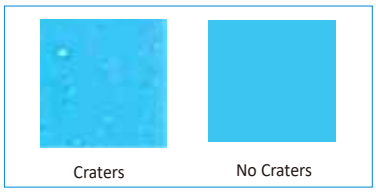


The first two factors depend strongly on the operator. The third factor can be controlled by the paint formulator. Lowering the surface tension of the liquid leads to smaller droplets under the same spray conditions and improves the flow of the single droplets after application.

Craters and Pinholes:

Craters and pinholes are caused by liquid or solid contamination present on the substrate or in the paint, or from the surroundings, before the drying process starts. The reason for the formation of craters is the difference in surface tension between the liquid paint and the contaminant. Such defects increase, as surface tension differences grow. By lowering the surface tension of the liquid, such defects can be avoided.

Pinholes are craters, where the liquid has not formed a homogeneous layer, thereby leaving a depression which penetrates to the substrate.



Fish Eyes:

Fish eyes are caused by insufficient substrate wetting. This occurs when the surface tension of the liquid paint is higher than that of the substrate and no spreading takes place on its surface. Spreading is improved by lowering the surface tension of the liquid.

Telegraphing:

Telegraphing (ghosting) occurs, when areas of different surface tension on the substrate are formed by wiping, by residual traces of a cleaning liquid or by finger prints. These marks appear on the surface of the applied paint film. This effect is clearly seen when the substrate/base coat contains interfacial active substances.

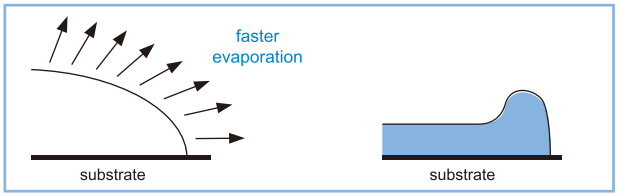
Air-draft Sensitivity:

Local differences in surface tension of the paint caused by non-uniform evaporation of the solvent can cause air-draft sensitivity. Locally confined evaporation leads to an increased surface tension in the film. Rupture of the film can take place when this surface tension rises above the substrate's surface tension, and de-wetting takes place. This problem is avoided by lowering the surface tension of the liquid.

Edge Crawling:

Edge crawling is found at the edges of the substrate, because the surface of the applied paint film is larger at the edges. Here faster evaporation of solvents takes place, leading to a stronger increase of surface tension than in the rest of the liquid film. A higher surface tension causes the surface to crawl, because it is trying to adopt a smaller overall size.

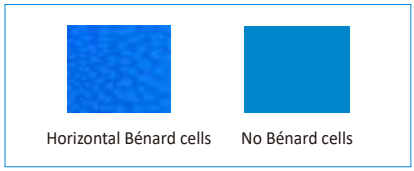
This problem is avoided by lowering the surface tension of the liquid.



Floating (Bénard cells) and Silking:

Floating and silking are related to processes taking place in the liquid paint during the drying phase. Differences in the density and surface tension give rise to turbulent flow of material from the lower to the upper part of the film. In pigmented systems, the pigments settle in different areas depending on their mobility. On horizontal surfaces, this floating is seen as hexagonal patterns; so-called Bénard cells. Silking has the same origin but is limited to vertical surfaces and shows as line-shaped patterns.

These defects can be avoided by minimizing the surface tension differences occurring during the drying process.



Leveling

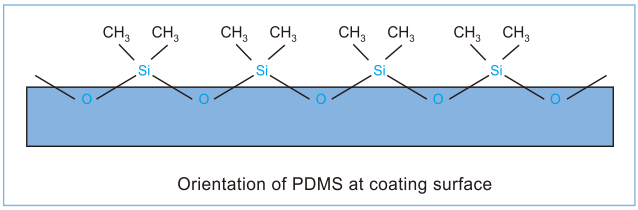
All these defects are caused by differences and changes in the surface tensions of the liquid paint, substrate and contaminants.

With "Wetting" it was shown that effective wetting of a solid takes place when the liquid has a lower surface tension than the solid. When the surface tension of the liquid paint is high, the system is more sensitive to wetting defects. In general, modern synthetic resins have a higher surface tension than those based on natural fatty acids. Aqueous systems have a high surface tension due to their polarity.

The main solution to these problems is to adjust the surface tension of the liquid to that of the solid. Therefore additives to improve leveling need a low intrinsic surface tension and a high mobility towards the interface they have to influence.

Slip

An additional requirement for a coating is good slip. This so-called "slip" improves the aesthetic impression and helps to protect the film against scratches, metal marking and dirt. Slip properties are only achieved by using long chain polysiloxanes containing dimethylsiloxane groups. The friction at the surface caused by irregularities is reduced by the lubrication effect of the dimethylsiloxane groups concentrated at the surface, without producing a greasy layer.



Orientation of PDMS at coating surface

The slip can easily be determined by slip angle measurement or by touch.

Protection by slip is most important in the initial drying stage, where the surface is still vulnerable to mechanical influences. Only a small amount of silicone-leveling agent is needed for the optimum slip performance, whereas over-dosage can lead to unwanted side-effects.

A common unwanted side-effect of some polyether-modified siloxanes is their surface-activity, sometimes giving rise to foam stabilization. Often, therefore, the simultaneous use of a defoamer is recommended.

Alternatively, an alkyl-modified siloxane or polyacrylate can be used as leveling agent to avoid foam formation during paint application.

Leveling Agents

The UNIQCHEM range of slip and leveling agents are based on the following chemical families:

•**Long chain polysiloxane**s are the most common leveling agents in the coating industry. Pure polydimethyl siloxanes are not used in the UNIQCHEM range due to their incompatibility with many resins. To improve this, the polydimethyl siloxane backbone is modified with alkyl or polyether side chains. In addition, reac- tive groups such as isocyanates, double bonds, hydroxyl groups and acid groups can be incorporated, leading to the advantage that the leveling agent can be crosslinked into the film. They are suitable for solventborne systems, waterborne systems or both, depending on the type of side-chain used.

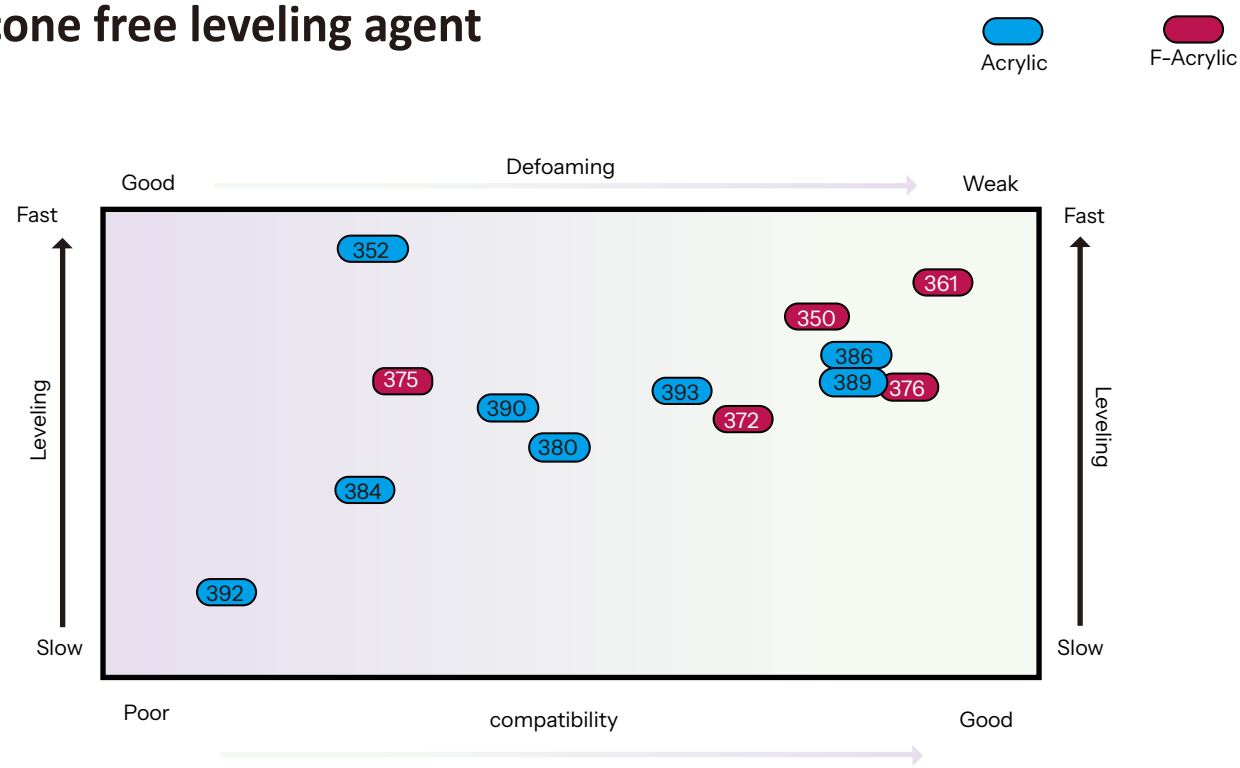
•**Polyacrylates** are produced from special monomers with a low surface tension. These structures move to the interface, equalizing the surface tensions.

They are known for not causing inter-coat adhesion problems in the dry film, and depending on their modification, they can be used in solvent- or waterborne systems.

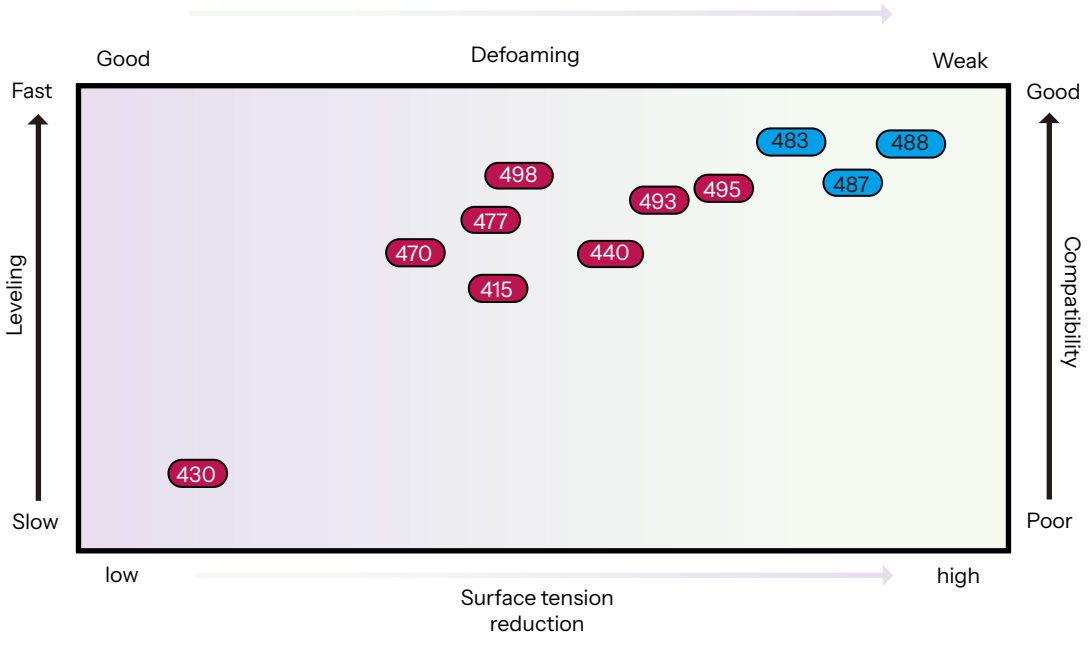
•**Fluor modified Polyacrylates** are produced from special monomers with a low surface tension. Due to the fluo modification you will achieve also good wetting performance on the solid liquid interface. These additives are also known for not causing inter-coat adhesion problems in the dry film, and depending on their modification, they can be used in solvent-, solvent free or water-based applications.

•**Short chain polysiloxanes** were developed to bring silicone-based leveling agents which will not affect inter- coat adhesion. The main benefit is found in water- based system.

Silicone free leveling agent



Silicone containing wetting, flow and slip agent



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