MÜNZING
CREATING ADDITIVE VALUE

Technical News
No. 04

TAFIGEL®
RHEOLOGY MODIFIERS

Specific rheology adjustment for applications.

1 Rheology and Rheometers

Paints are used to equip surfaces with additional functions. The application spectrum lasts from classical protection of surfaces against ageing and corrosion to the achievement of specific visual or functional effects like in complex automotive metallic coatings or self-cleaning surfaces. In the development of a coating the most attention is paid to the optical and protection properties of the film. In contrast the rheological behaviour of the system is often neglected (Figure 1).

However, coatings have to be ideal applicable. The desired film thickness should be achieved with simple application and good leveling in one operation. In architectural coatings the individual impression of the in-can viscosity during the first stirring is of special importance for the applicator. Moreover low spattering tendency and adequate sagging resistance are needed to stand out from the competition.

Thus, the rheological behaviour of a coating at shear has an influence on the entire life cycle of this fluid starting from production via storage to easy application by the end user (Figure 2).

Figure 1 | Annoying brush marks in the application of a wall paint.

During production the viscosity of a paint is often adjusted with standard thickeners to a desired level at a specific shear range only, usually with flow times from the ISO cup or with rotational viscometers.

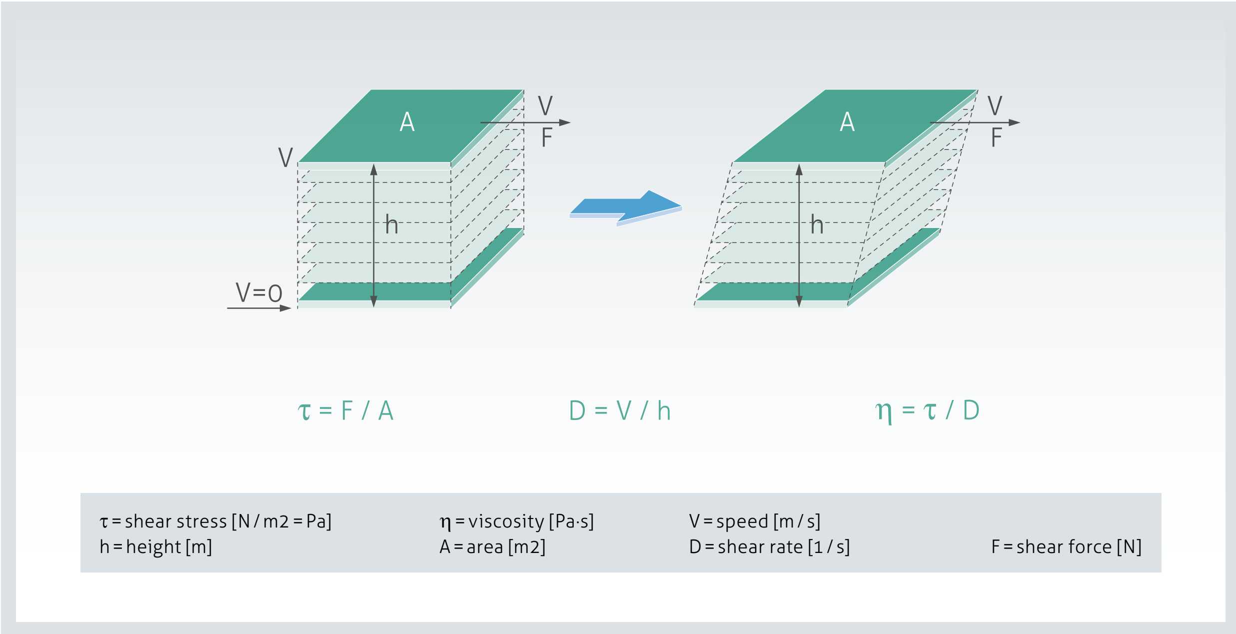

Figure 2 | Viscosity and shear rate in shear deformation of a fluid.

The rheological profile of paints however can not be adjusted this way sufficiently as viscosities at different shear rates have very different technical implications in the life cycle of a coating (Figure 3). A complete rheology profile can be recorded with quite expensive rheometers only. Therefore they are still not available in all research laboratories. With their dynamic and non-linear test methods like frequency or amplitude sweeps additional important properties can be judged, like spattering of a paint or settling tendency of a pigment concentrate.

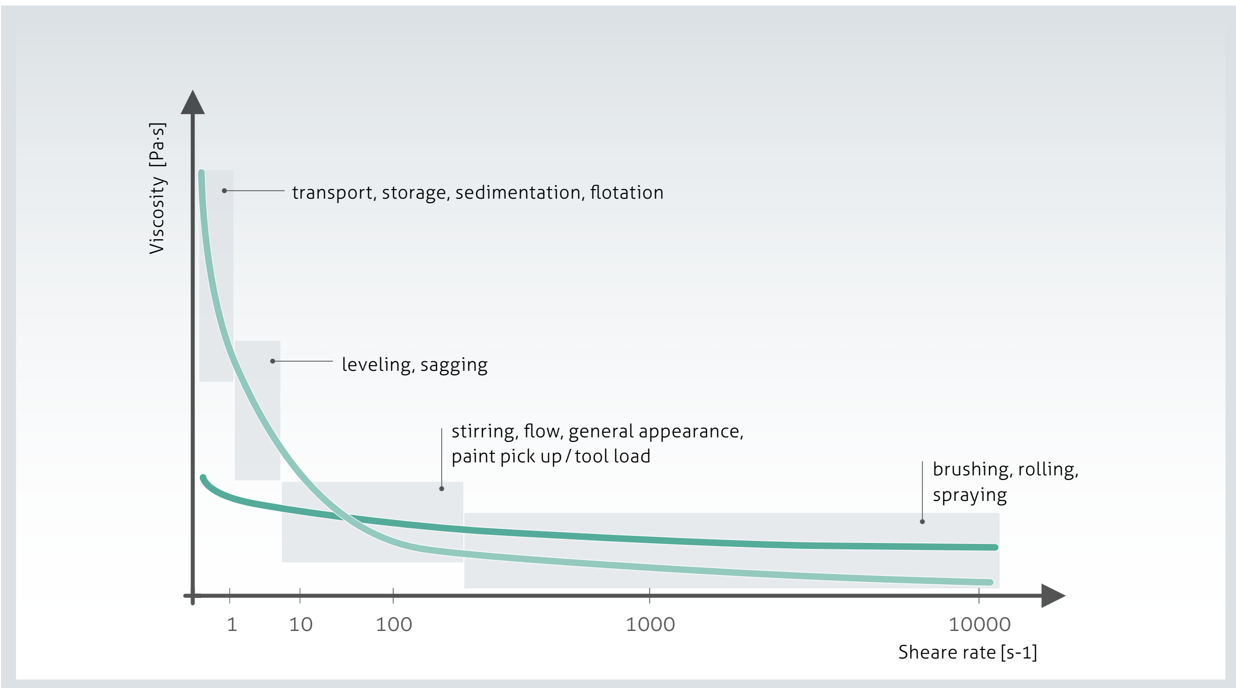

Figure 3 | Implication of rheology and application properties.

2 Thickener Types

2.1 Cellulose and Acrylic Thickeners

The classic thickeners based on cellulose (CE) and standard acrylates (Alkali Swellable Emulsion, ASE) create in general strong pseudoplastic rheology profiles. Here the thickening mechanism is based on long, entangled molecular structures, which thicken the aqueous phase with their voluminous chemical structure. These thickeners show a good sagging resistance, but often associated with poor flow and high elasticity and thus spattering. Additionally they have a negative impact on water resistance, which is especially important for anti-corrosion or façade coatings.
Furthermore coatings containing cellulose thickeners are more susceptible to bacterial contamination in the packaging as well as in the dried film. On the other hand only a sufficient dosage of cellulose derivatives gives the required open time for the application of coatings, especially outdoors.
Standard acrylic thickeners are less susceptible to bacterial attack. On the other hand they are very sensitive to pH variations. A stable thickening plateau is achieved in the pH range of about 8–10 only. If the pH value of the system
decreases during storage – e.g. due to ageing processes – this can result in a strong reduction of viscosity and thus storage stability of the coating system.

2.2 TAFIGEL® PUR – Associative Polyurethane Thickeners (HEUR)

The thickening mechansim of associative polyurethane thickeners (HEUR) is completely different. Due to their hydrophobic-hydrophilic-hydrophobic structure they form aggregates in aqueous systems in form of micelles. Unlike classical surfactants a thickener molecule can be part of more than one micelle and can link them in this way. The hydrophobic end groups of the thickener molecules are forming these bridged micelles with each other and beyond this interact with the hydrophobic binder molecules or other hydrophobic ingredients of the formulation. This association causes an immobilization of the formulation components and results in thickening (Figure 4).
Under shear this associative network between polyurethane thickeners and hydrophobic components of the systems – mainly the binder – is temporarily destroyed. Once shear energy is taken away the network rebuilds after a short while (relaxation). Macroscopically such coating systems show much better leveling properties than formulations based on cellulose and acrylic thickeners.

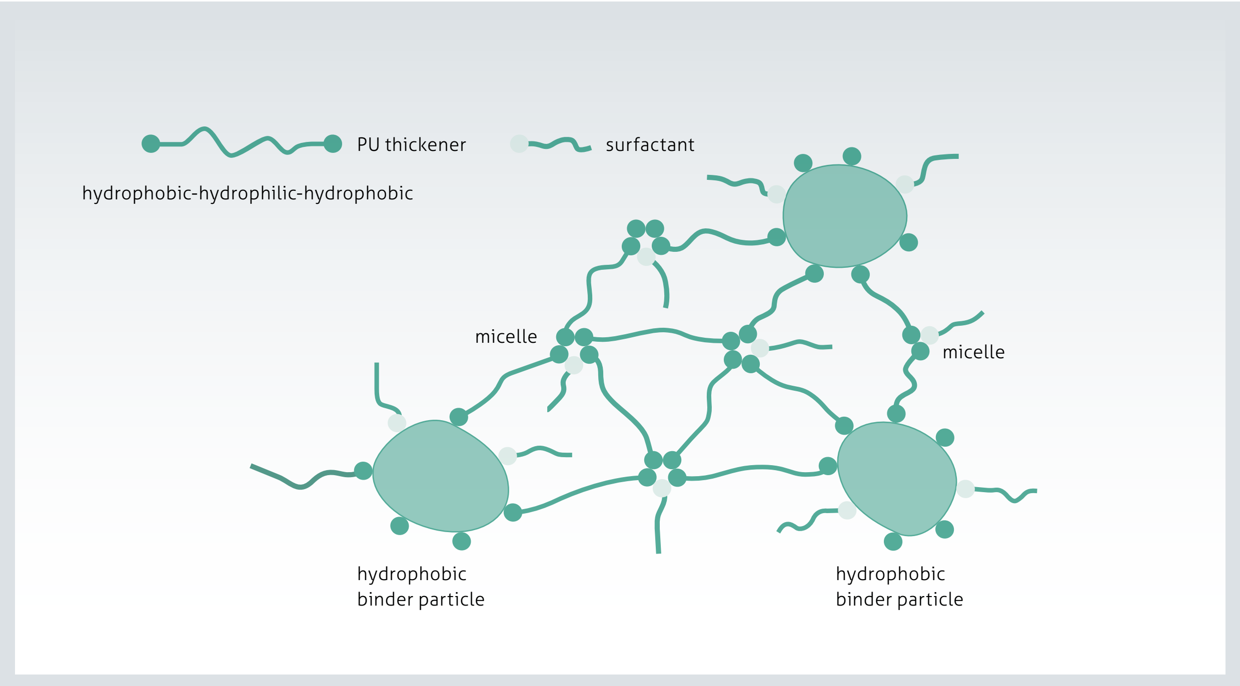

Figure 4 | Formation of an associative network with TAFIGEL® PUR thickener.

In the same way polyurethane polymers are able to stabilize other hydrophobic and hydrophilic components of the formulation. Either their hydrophobic or hydrophilic polymer segments can interact with e.g. pigments and can provide additional wetting and dispersing effects. The colour acceptance in tinting is increased and settling tendency and rub-out problems are reduced.

In addition the molecular weight of polyurethane thickeners is in general well below the ones of the cellulose and acrylic thickener types (Table 1). Combined with lower elastic properties this leads to significantly decreased spattering tendency of dispersion paints (Figure 5), a strong reduction of brush marks and higher gloss.

The chemical design of the hydrophobic-hydrophilic-hydrophobic segments allows to vary the associative behaviour of the polyurethane thickeners and to adjust the achievable rheology profile in a broad way (Figure 6).

A more newtonian flow property can be created with less hydrophobic end groups and a longer hydrophilic polymer chain in the middle, like in TAFIGEL® PUR 45, TAFIGEL® PUR 80 or TAFIGEL® PUR 85. In this way the viscosity at high shear can be raised specifically. These thickeners create excellent leveling, high gloss and brush drag. The paint transfer in one application is increased. With higher dosage a higher film thickness in one application can be achieved. In this way it is possible to compensate a weak hiding power of a coating with reduced titanium dioxide content.

Strong pseudoplastic rheology profiles can be achieved with short polymer chains terminated with strong hydrophobic end groups like in TAFIGEL® PUR 60, TAFIGEL® PUR 61, TAFIGEL® PUR 64 and TAFIGEL® PUR 65. Emulsion paints, adjusted with these rheology modifiers, possess a high sagging resistance and excellent sprayability. A typical application is e.g. industrial thick layer spray coating for door and window frames.

Medium pseudoplastic polyurethane thickeners like TAFIGEL® PUR 40, TAFIGEL® PUR 41, TAFIGEL® PUR 44, TAFIGEL® PUR 48, TAFIGEL® PUR 50 and TAFIGEL® PUR 52 create an universal rheology profile. They can be used for brush and roller as well as for spray applications. They generate their strength in combination with cellulose thickeners in wall paints. While the cellulose derivative provides the required open time, the TAFIGEL® PUR improves leveling and reduces spattering, e.g. at brisk roller application (Figure 5).

Due to their different thickening mechanism TAFIGEL® PUR types are in general also suitable for cationic systems like stain blockings.

Additive	Molecular Weight [g/mol]
Surfactant / Emulsifier	~ 10^2
Dispersing Agent	~ $10^3 – 10^4$
Polyurethane Thickener	~ 10^4
Acrylic Thickener	~ 10^5
Celluloseether	~ 10^6

Table 1 | Molecular weight of selected coatings additives.

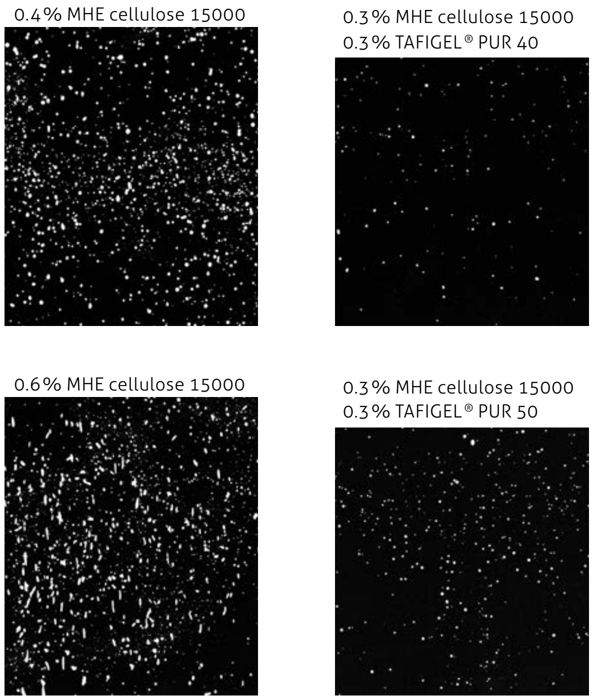

Figure 5 | Spattering tendency of an architectural coating with different thickeners during fast roller application.

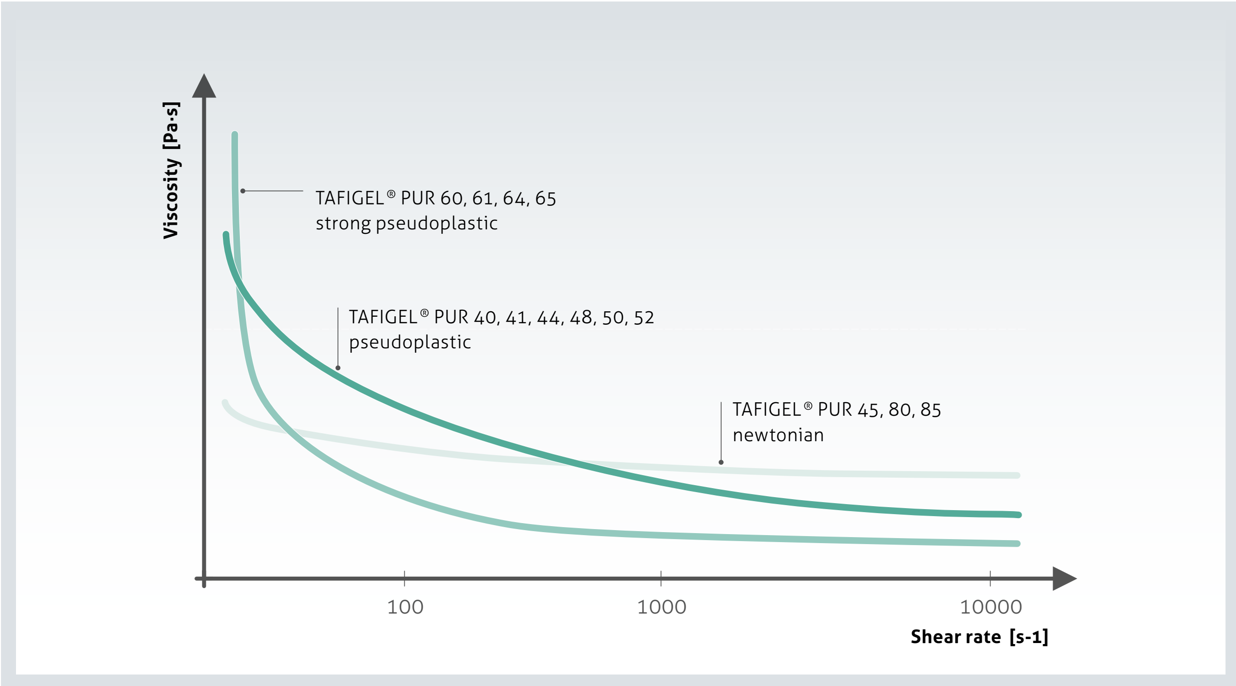

Figure 6 | Rheology rofiles of different TAFIGEL® PUR thickeners.

2.3 TAFIGEL® AP – Associative Acrylic Thickeners (HASE)

There are numerous applications, in which polyurethane thickeners do not show sufficient efficiency. If the binder content is low or very polar binders such as vinyl acetate or polyurethane are used, less hydrophobic-hydrophobic interactions occur. In these systems sufficient sagging or settling resistance usually can be achieved with higher thickener dosage only. For those difficult-to-thicken systems the TAFIGEL® AP series was developed.

TAFIGEL® AP 10, TAFIGEL® AP 15 and TAFIGEL® AP 16 are strong hydrophobically modified acrylic polymers in aqueous dispersion (HASE). They can be easily incorporated into aqueous systems and develop a stable level of thickening in the pH range of 8–10. The achievable rheology is depending on the used binder system. In comparison to conventional acrylic thickeners they possess significantly lower pH sensitivity due to their more associative character. They provide excellent efficiency for example in pigment concentrates or emulsions, as they are equally capable to stabilize the water phase as well as the hydrophobic components with their hydrophobic and hydrophilic interactions.

TAFIGEL® AP 20 and TAFIGEL® AP 30 are special acrylic thickeners with a very high pseudoplasticity. With their help formulations with very high sagging and sedimentation resistance can be formulated, e.g. textured plasters. Due to their special pre-neutralized delivery form they can be stirred directly into aqueous coatings without pH correction. Thus, they can be used for post-correction of viscosity at the end of production.

Acrylic thickeners are not suitable for systems with a pH less than 7. Settling in such systems can be prevented with e.g. suitable layer silicates.

Summary

TAFIGEL® PUR polyurethane and TAFIGEL® AP acrylic thickeners can be combined easily with each other as well as with all known thickener types, often with synergistic effects. Their major strength are the specific adjustable rheology profiles. They possess better leveling properties than classical thickeners and higher gloss levels are achievable. The higher water and scrub resistance and the higher resistance against bacteria are further strong points. Open time and storage stability can be improved by combination with cellulose thickeners.

The selection of suitable thickeners for a coating depends crucially on its scope and technique of application. Table 2 helps to select thickeners for different types of applications in architectural and industrial coatings.

Through proper selection and clever combination the rheological behaviour can be adjusted appropriately and user-friendly. In a more and more competitive environment this is an ideal way of Creating Additive Value!

Application	Recommendation
Brushing	TAFIGEL® PUR 40, 41, 44, 45, 48, 50, 52, 80, 85
Rolling	TAFIGEL® PUR 40, 41, 44, 45, 48, 50, 52, 80, 85
Spraying	TAFIGEL® PUR 60, 61, 64, 65
Dipping	TAFIGEL® PUR 60, 61, 64, 65
Flow / curtain	TAFIGEL® PUR 40, 41, 44, 45, 48, 50, 52, 80, 85
Rolling (industrial) / printing	TAFIGEL® PUR 40, 41, 44, 45, 48, 50, 52, 80, 85
Desired coating property	**Recommendation**
Gloss	TAFIGEL® PUR 45, 80, 85
Sagging resistance, storage stability	cellulose, TAFIGEL® AP series, TAFIGEL® PUR 60, 61, 64, 65
Anti-settling for heavy pigments	layer silicates, cellulose, TAFIGEL® AP series
High water and scrub resistance	TAFIGEL® PUR series
Open time	cellulose
Special systems	**Recommendation**
PU, EVA binders	TAFIGEL® PUR 60, 61, 64, 65, TAFIGEL® AP series
Silicone resins	TAFIGEL® PUR 45, 80, 85
Anti-corrosion	TAFIGEL® PUR series
"Flop"-effect with metallic coatings	TAFIGEL® AP series

Tabel 2 | Thickener selection guide for different architectural and industrial applications.

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