facts

Xanthan Gum – a bio-based hydrocolloid for paints

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Introduction

Paints have played a role in the everyday life of mankind for tens of thousands of years. Starting with early art on cave walls, they are now used to cover almost all man-made surfaces. Paints are a special type of coating with the main function of beautifying surfaces while at the same time protecting them and extending their lifespan.

Paints are produced in different forms: liquid dispersions based on water or organic solvents, and powders, mainly used in the automotive and electronics industry.

More than 50 years ago, most liquid paints were solvent-based. Such paints are easy to apply, dry fast and provide no medium for microbiological growth. However, on the flip side, there is the strong odour emitted during evaporation as well as the potential hazard to human health and the environment, and not least the risks associated with combustible gases which can form during the transport, storage and use of such paints.

With growing awareness for health and the environment in the late seventies and subsequent years, the use of organic solvents has been gradually restricted or stopped through voluntary efforts and legislation supporting this trend. Today, the majority of architectural paints are water-based, especially do-it-yourself products. Paint producers consequently spared no effort in developing high-quality paints free of organic solvents. Many such dispersion paints are equal or even superior to their organic solvent-based counterparts in terms of performance [1,2].

Thickeners in paints

Water-based dispersion paints, widely known as emulsion paints or acrylic paints, mainly consist of a binder (the film-forming component), pigments (providing the colour of the paint), water and additives. Additives have a major influence on the performance of a paint formulation. Along with fillers, dispersants, defoamers, preservatives, film-forming auxiliaries, they also include thickeners. The thickener content is typically between 0.1 and 0.5%.

Thickeners and stabilisers are essential ingredients. They give the desired rheological properties and contribute to the overall stability of the product. Depending on the required application, various thickener systems are available. Xanthan gum is the right choice for applications where a high yield value and pseudoplastic behaviour are required.

Xanthan gum is a natural high molecular weight polysaccharide. It is produced by the natural process of fermentation of carbohydrates from renewable sources. Xanthan gum can be used as an ingredient for paints certified under different ecolabels.

It is a very effective stabiliser, soluble in both cold and hot water, stable at a wide range of pH and is generally inert to other chemicals. The addition of xanthan gum to water changes the rheological properties from Newtonian to pseudo-plastic, thus exhibiting high viscosity at rest but thinning under shear stress. The high viscosity at low shear rates and at rest results in stable suspensions of insoluble ingredients. This enables good stabilisation of the paint during storage, as well as good adherence to the wall. Paint thickened with xanthan gum exhibits shear thinning properties during application with a brush, roller or spray, but with minimised dripping in between applications.

Paint production

Water-based dispersion paints are typically produced in two steps:
- Production of the pigment paste
- Subsequent mixing with the rest of the paint formulation, the “let-down” to obtain the final dispersion paint

A pigment paste is made by milling the pigment, e.g. titanium dioxide for white paint, together with water and additives to obtain the right granule size to form colloidal dispersions. For inorganic pigments, colloidal dispersions with granule sizes of ca. 5–1000 nm are needed for the best covering power. Thickeners are added to the pigment paste before milling to adjust the viscosity, which is important for optimum power transmission during milling.

In the let-down, the binder and further additives are mixed and then combined with the pigment paste. The role of the thickener in the final dispersion paint formulation is to stabilise the suspension during storage and to act as an anti-syneresis agent due to its high water binding capacity. It also ensures optimum rheological properties for smooth application and distribution by brush, roll or spray, followed by fast viscosity build-up once applied onto the surface.

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Performance of thickeners

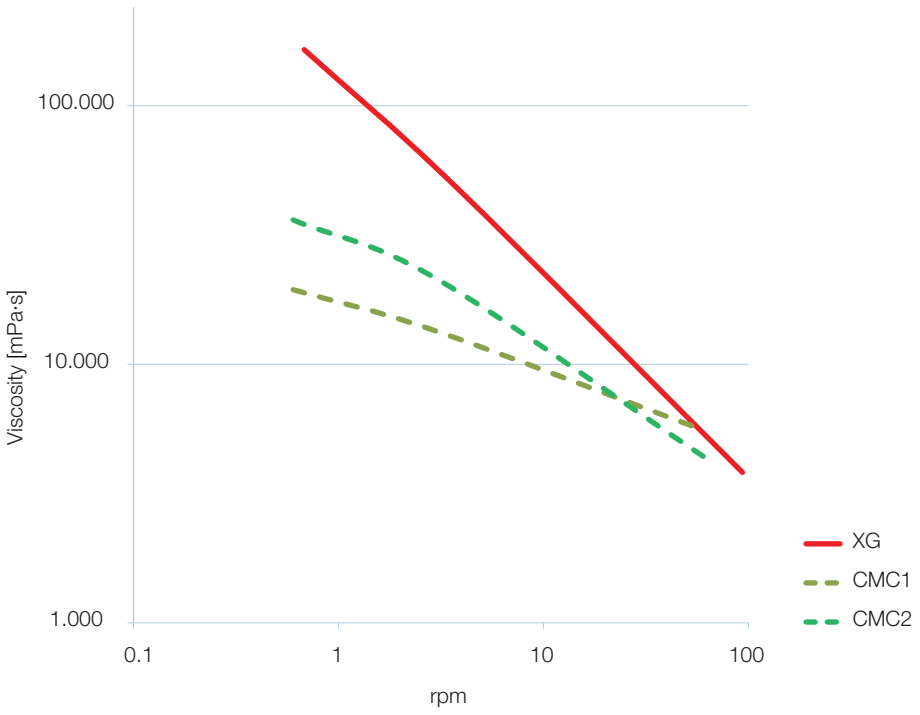
The performance of Jungbunzlauer xanthan gum at different stages of paint production has been investigated by comparing different types of xanthan gum with other commonly used thickeners, namely a hydrophobic modified acrylic swellable copolymer emulsion (HASE) and two types of carboxymethyl cellulose: CMC1, characterised by delayed viscosity, and CMC2, a non-ionic water-soluble cellulose ether [3].

In order to achieve a comparable viscosity, the dosage of xanthan gum was only 40% of the dosage of HASE, CMC1 and CMC2.

It is important to compare the viscosity of these thickeners in standardised conditions. The specified viscosity of CMC is often very high, up to 15,000 mPa·s at 2% concentration, while the specified viscosity of xanthan gum is typically between 1,200 –1,800 mPa·s, but at only 1% concentration. By simply comparing these values, it appears that CMC is much more effective in terms of viscosity, but once the testing conditions are taken into consideration, it becomes obvious that the conditions themselves have a huge impact on the viscosity values.

When comparing comparing Jungbunzlauer xanthan gum (XG) with CMC1 and CMC2 in standardised conditions – a concentration of 2% and testing at 0.6 rpm, 3 rpm and 60 rpm in standardised tap water – we find that in fact xanthan gum has higher viscosity, especially at low shear rates, indicating good stabilisation of the paint. Xanthan gum is also more pseudoplastic, i.e. more thinning at high shear rates, making it ideal for easy application, e.g. spraying.

Figure 1: Viscosity of XG compared to two different CMCs in identical conditions



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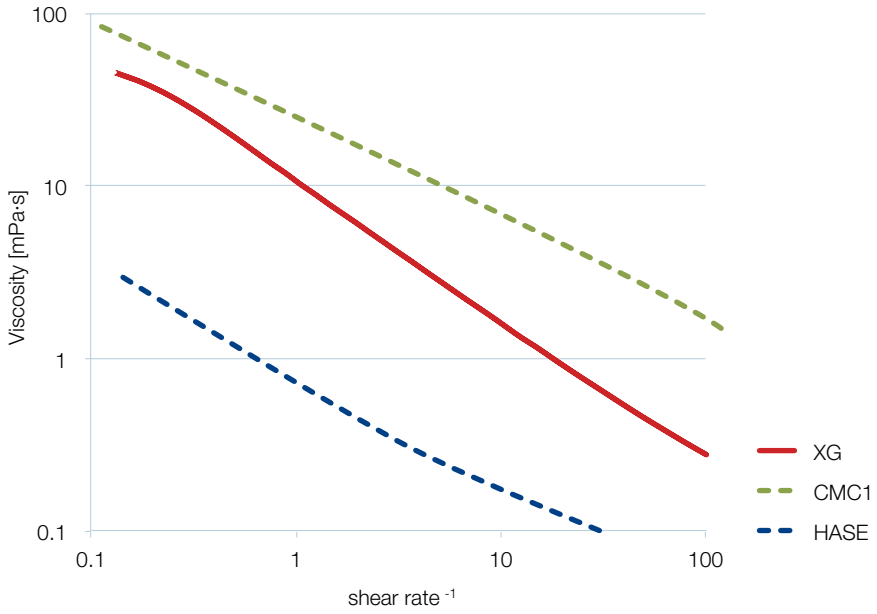
Thickeners in pigment pastes

Thickeners provide optimum rheological properties in pigment paste during the milling process. Two pigment paste formulations, one based on titanium dioxide (TiO_2, white) and the other on iron oxide (Fe_2O_3, red), have been prepared and milled. The formulations contained one thickener, either 0.2% xanthan gum, 0.5% HASE, or 0.5% CMC1, respectively.
The pigment pastes were tested for viscosity (figure 2), with all xanthan gum samples exhibiting similar viscosities, therefore only one representative sample is shown below. The CMC1 formulation was thicker, the HASE thinner than the xanthan gum formulations.

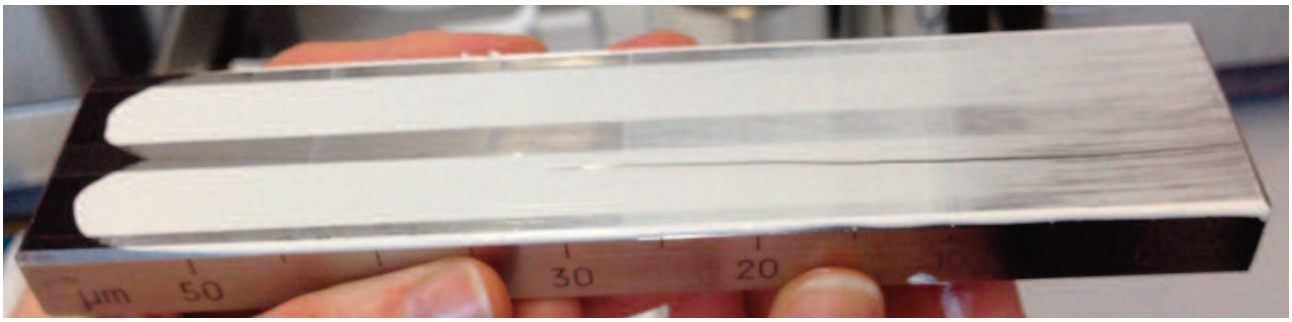
Qualitative evaluation of workability, sedimentation, bubble formation and wettability showed very different behaviour of HASE and CMCs compared with xanthan gum. The HASE formulation was overall the most difficult to work with, had poorer wettability and formed larger bubbles than other formulations.

Figure 2: Viscosity of iron oxide paste with different thickeners



The different formulations were also compared using a grindometer (figure 3) to detect large, poorly milled pigment particles. The test confirmed all thickeners performed satisfactory with pigment particle sizes below 40 µm.

Figure 3: Grindometer test



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Thickeners in dispersion paints

In order to gain insight into the thickeners performance in the final dispersion paint formulations, two different dispersion paints have been prepared: a classic dispersion paint with a polyacrylate binder and a silicate-based paint.

a) Classic dispersion paints have a typical pH of 9–10, they are suitable for all rooms and surfaces, and are available in any colour.
b) Silicate paints mainly contain minerals as binders, very often potassium silicate. The typical pH is 13, therefore good protection of the skin and eyes during application is essential. However, the high pH inhibits the growth of micro- organisms and no preservatives are needed. Therefore, silicate paints are particularly suitable for allergen-free areas and children's rooms, but also for any other room.

As was the case in the pigment paste formulations, the xanthan gum concentration here was 0.2% and that of HASE and CMCs was 0.5%. In terms of viscosity, the formulation with Jungbunzlauer xanthan gum fared well, with the HASE formulation being thinner and the CMC1 formulation being thicker. The viscosity is one indication for the flow property of the paint. Xanthan gum and HASE guarantee a mostly good flow of the paint, whereas the CMC samples contained lumps and were pasty (figure 4) [4].

Figure 4: Different paint consistencies

Good

Thick

Pasty

Another important rheological feature is the thixotropy. Thixotropy is when shear thinning and shear thickening occur with a time lag. Xanthan gum has low thixotropy, which leads to a fast thinning when shear is applied, which is helpful for spray application, for example, and also has a fast viscosity build-up once the product is applied to the wall, which allows a structured film to form. HASE and CMC have slightly higher thixotropy than xanthan gum. Furthermore, the tests showed that the thixotropy of the overall paint formulation is also influenced by further additives.

Indications of optimum pigment milling are as follows:
- Covering power on black and white surfaces (figure 5), tested by determination of the L*a*b colour space: the lightness (L) and the blue-yellow value (b) are measured in the white paint and compared on black and white surfaces. The lightness should be high and the yellowness low, with a small difference between the black and the white surfaces. The component "a" represents the red-green axis and is not relevant for white paints.
- Surface profile, tested using a perthometer: a sensor scans the roughness of a painted surface. A smooth surface indicates good pigment milling.

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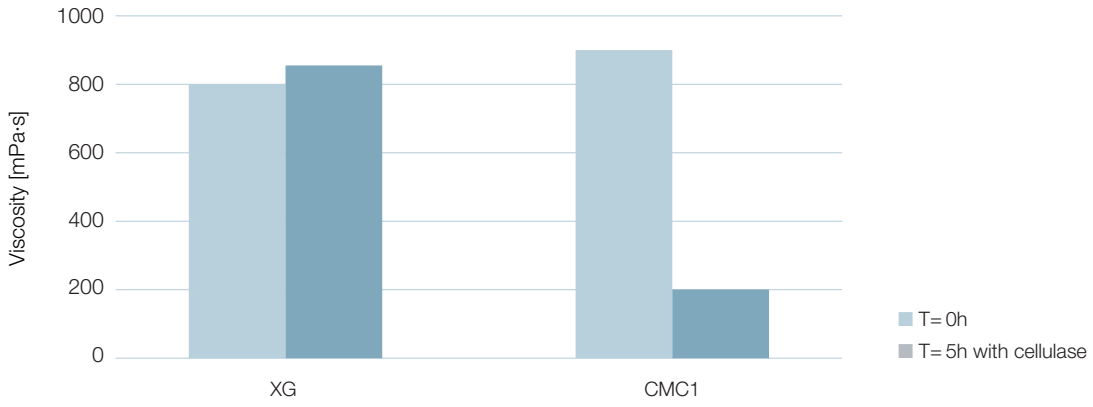
Figure 5: White paint stripe on black and white paper

While the covering power and lightness were good for all samples, the surface profile results for xanthan gum were overall better than for the CMC and HASE thickeners, meaning that an even, smooth film of paint was formed.

Paints are not sterile products and enzymes can be present as soon as microorganisms enter the product. Enzyme stability is therefore crucial for paints to remain stable over time. Thanks to its molecular structure, the backbone of the xanthan gum molecule is sterically protected against enzyme degradation, so that its stabilisation and thickening properties are unaffected by the presence of enzymes. When cellulase is incubated for five hours in paint containing xanthan gum and another containing cellulose, the xanthan formulation viscosity remains stable while cellulose viscosity, unsurprisingly, decreases.

Figure 6: Cellulase stability of Jungbunzlauer xanthan gum (XG) compared to cellulose (CMC1)



Summary

Overall, xanthan gum is a product with a high degree of functionality in pigment pastes and paints. Its performance is equal or even superior compared to typically used thickeners regarding many aspects, such as providing optimum rheology for pigment milling, workability, flow properties, or enzyme stability. Xanthan gum is highly pseudoplastic; its very high viscosity at low shear and rest enables good stabilisation of the paint during storage. Increasing shear leads to thinning, which allows easy application of the paint onto the wall. Jungbunzlauer xanthan gum is a naturally derived, eco-friendly product, and its high efficiency ensures a very good cost-in-use performance.

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References

[1] Cf. www.wpcia.org

[2] Cf. www.paint.org

[3] All tests, except the flow test, were carried out at Steinbeis-Zentrum für Pulverlacke, Hochschule Esslingen, Prof. Dr. Peter Thometzek, www.thometzek.de

[4] The flow test was carried out by Institut für Lacke und Farben Magdeburg GmbH www.lackinstitut.de

About Jungbunzlauer

Jungbunzlauer is one of the world's leading producers of biodegradable ingredients of natural origin. We enable our customers to manufacture healthier, safer, tastier and more sustainable products. Due to continuous investments, state-of-the-art manufacturing processes and comprehensive quality management, we are able to assure outstanding product quality. Our mission "From nature to ingredients®" commits us to the protection of people and their environment.

Jungbunzlauer offers different grades of xanthan gum for food application as well as in pharma and personal care products.

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