A novel biopolymer-based coating additive

Performance the natural way

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A micronised biopolymer additive for coatings is based entirely on renewable resources and is fully biodegradable. Normal addition levels combine excellent matting with good visual, tactile and mechanical properties. Performance is particularly efficient in hard-to-matt 100 % solids UV coatings.

Coating additives belong to a broad and diffuse category of key components used in a coating formulation. The function of any additive is very specific in nature and provides a range of properties to a coating.
Wetting and dispersing additives, for example, enhance uniformity of pigment distribution while rheology additives improve the flow behaviour of the coating formulation. Defoamers and levelling agents play an important role with respect to the final coating quality. Within the same category, matting agents strongly influence the appearance of a coating and sometimes even its haptic properties. A novel biopolymer-based additive designed for matting is introduced below.
Increased public awareness about sustainability and the preservation of nature leads to a high demand for eco-friendly products and even to new regulations. Thus, the need for innovative and "green" solutions is greater than ever before and involves all the components of a coating formulation, even if used only in small quantities.
Biotechnology has opened the door to an entirely new matting additive with a so far unprecedented combination of properties compared to conventional matting agents, such as waxes and silicas. It is based on a biopolymer, which is obtained by bacterial fermentation from sugars. The product originates from renewable resources, is fully biodegradable and GMO-free (see *Figure 1*).

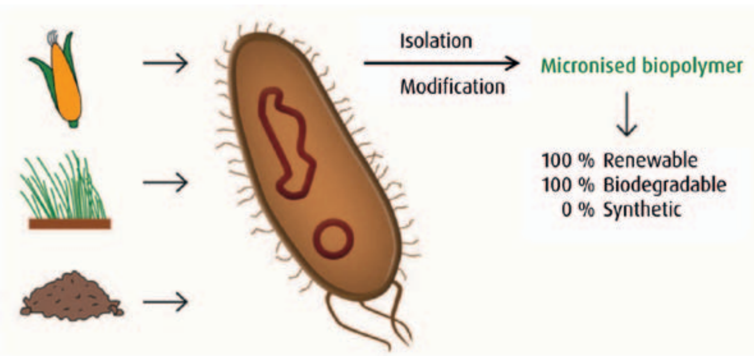


Figure 1: Origins of the new matting additive created through biotechnology

Low solvent levels make matting difficult

In recent years, the development of solvent-free formulations has been intensively promoted, partly within the perspective of creating more eco-friendly products. The omission of solvents results in new challenges. While conventional coatings are relatively easy to matt because the emissions cause film shrinkage upon hardening, solvent-free systems, such as 100 % UV curable systems for example, are notoriously difficult to matt.
Silica matting agents are very common and efficient in most coating systems. However, the amount of silica needed in solvent-free systems, especially for fully matt coatings, is significantly higher than in other coatings.
Untreated silica matting agents often cause a strong increase in viscosity and add additional thixotropy. Thus higher amounts of reactive diluents are needed, or specially designed wetting and dispersing agents have to be used in order to reduce the viscosity, to give Newtonian flow behaviour and to provide anti-settlement properties.
There are also many organically modified silica matting agents available which do not influence the viscosity significantly, but these are less efficient in gloss reduction and often exhibit foam stabilisation and less transparency. In general, wax additives do not influence viscosity as much as silica, but they are not efficient enough to create low gloss surfaces.
With some amide waxes, unwanted side effects such as foam stabilisation and haziness are also observed. The benefits of using wax additives, such as modified HDPEs, are improved film properties, for example, mechanical resistance. Often wax additives are used in combination with silica because film properties such as scratch- and abrasion resistance may be improved.
Furthermore, polymer matting agents are likely to be used, because of their easy incorporation and moderate influence on viscosity. Nevertheless, they often fail to achieve the desired performance. Test results obtained with the novel biopolymer are presented below.

Matting efficiency tested in 100 % solids UV systems

The matting performance of the new biobased product was tested in three different solvent-free UV systems: a

polyester acrylate, a polyurethane acrylate and an epoxy acrylate, all containing a photoinitiator and DPGDA (dipropylene glycol diacrylate) as reactive diluent. Untreated and treated silica were tested for comparison.
The matting agents were incorporated into the formulations with a dissolver and after 24 hours they were applied with a bar applicator on contrast cards and cured with a mercury vapour lamp (120 W/cm, belt speed 5 m/min). The gloss of the cured films was measured at an angle of 60 ° with a "Micro-Tri-gloss" meter from Byk-Gardner.
The matting efficiency of the novel micronised biopolymer, which was commercially launched as "Ceraflour 1000", was excellent with no detrimental influence on viscosity. For example, an amount of 7.5 % biopolymer produced an increase of viscosity from 500 to 550 mPa.s. By contrast, 7.5 % untreated silica raised viscosity from 500 to 3,000 mPa.s in the same polyester acrylate system.
Compared to treated silica, the matting efficiency of the biopolymer is higher or at least equal in common UV systems (see *Figure 2*). In polyester acrylate and urethane acrylate systems the gloss could be reduced to 10-20 % at an angle of 60 ° with 7.5 % of biopolymer based additive. This performance is comparable to untreated silica and better than treated silica.
The incorporation of the biopolymer based additive is easy; no high shear force is needed. During incorporation dust and foam stabilisation were not observed.

Other matting challenges are met satisfactorily

In UV systems, obtaining a uniform gloss is often a major challenge. Even small variations in film thickness can generate differences in gloss. The polyester acrylate described above was applied with different film thicknesses and the gloss was measured. In contrast to other matting agents, such as treated and untreated silica, wax and organic polymer for example, it was observed that with the novel additive, the gloss level is fairly independent of film thickness (*Figure 3*).
The additive has also been tested in systems other than 100 % UV. In many waterborne 1K, 2K and UV systems good matting efficiencies can be observed. In most cases results similar to those with conventional matting agents are obtained. In solventborne systems the matting properties are better than with wax additives and in some cases match those of silica. The biopolymer can be combined with silica, polymer matting agents and wax additives.

Haze and transparency properties are excellent

Generally, a transparent coating is defined as being capable of transmitting light so that objects or images can be seen as if there were no intervening material. Incorporation of a matting agent into a coating has the effect that the light passing through the coating is partially scattered.

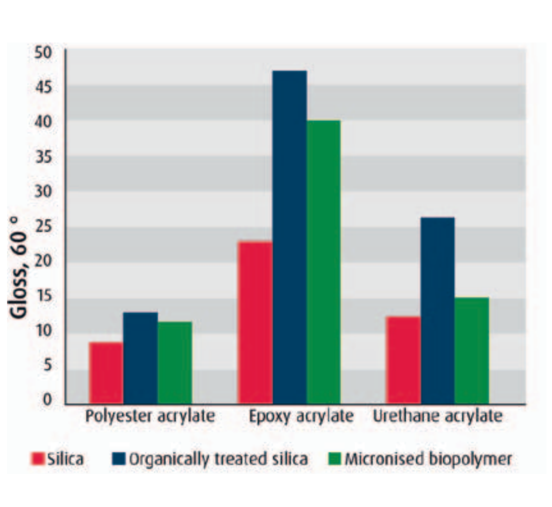


Figure 2: Gloss reduction of three selected additives in three common 100 % UV-systems (additive dosage 7.5 %, 20 µm dry film thickness)

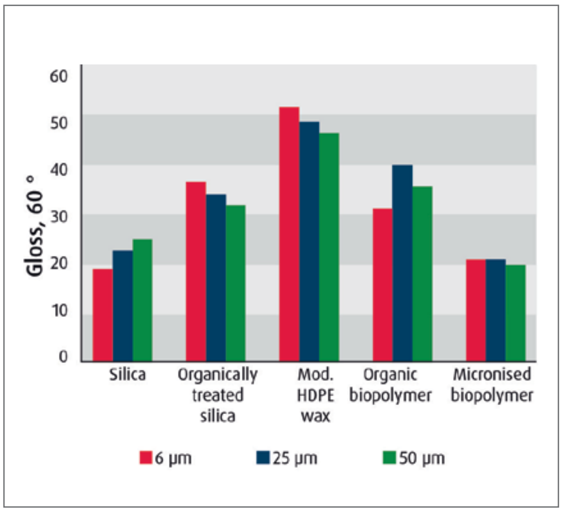


Figure 3: Gloss reduction of different matting agents at different film thicknesses (additive dosage 5 %)

Results at a glance

››› A micronised biopolymer additive for coatings has been developed which is based entirely on renewable resources and is fully biodegradable.

››› Normal addition levels provide excellent matting combined with a pleasant soft touch, outstanding clarity and see-through quality and improvements in some mechanical properties.

››› While it can be used in many different types of solvent-free, solventborne and waterborne coatings, matting in 100 % solids UV coatings is particularly efficient and is independent of film thickness.

››› The additive shows excellent storage stability, i.e. neither sedimentation nor creaming and no loss of efficiency, in UV systems.

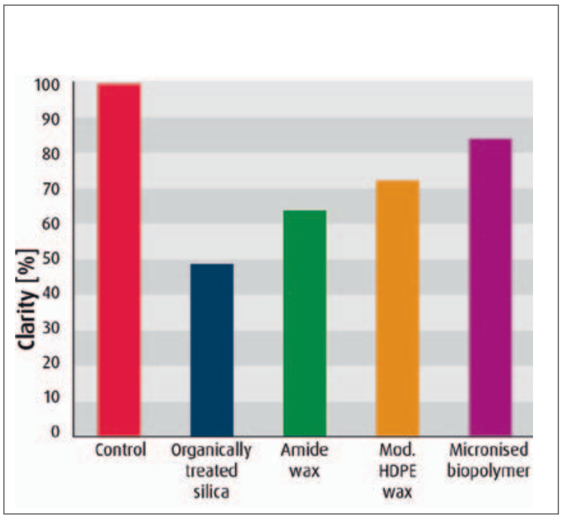
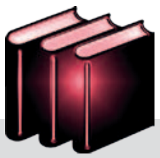


Figure 4: Coating clarity as a function of additive (additive dosage 2 %, 30 µm dry film thickness)

Our visual perception can clearly differentiate between wide angle scattering and narrow angle scattering. Wide angle scattering diffuses light in all directions and leads to a loss of contrast, also known as haze. The latter, narrow angle scattering, diffuses light in a small angular range with high concentration. This affects how fine details can be seen through the specimen, or in other words, it describes the clarity or see-through quality [1]. A high clarity is desirable for wood coatings, for example: the graining of wood should be clearly visible.
In order to evaluate coating clarity, the new biobased additive was compared to organic treated silica, amide wax and modified HDPE wax. The matting agents were incorporated with a dissolver into a 2K solventbased polyurethane system and after 24 hours the formulations were poured onto PE foils. The clarity was measured using a “Haze-Gard plus” instrument and results are summarised in *Figure 4*.
The haze value of the prepared films, measured with the same instrument, was 7 for the control, 22 ±1 for the coatings with amide wax, modified HDPE wax and the new biobased additive and 37 for the organic treated silica. The film containing the biopolymer showed a higher clarity in comparison to treated silica or wax containing films, thus the biopolymer additive is particularly suitable for coatings with reduced gloss accompanied by a high quality of transparency.
This high transparency was also observed in 100 % solids UV systems and in waterbased coatings. The orientation of the particles was very homogeneous in all systems. The cross-section of films, prepared with a drawdown on contrast cards with the above described 2K solventbased polyurethane system, was investigated by scanning electron microscopy. The images show a uniform distribution of the particles throughout the cross-section of the final coating (*Figure 5*).



Soft-touch effect is an added benefit

The haptic properties of an object describe the sensation of touching it and are a popular field in research. This has become increasingly important from the point of view of product competitiveness. As many objects, like furniture for example, are protected by coatings the haptic properties can be adjusted by the properties of the coating.
Good haptic properties can be considered as those provided by a smooth surface with a soft touch effect. In order to test the haptic properties, several samples were prepared based on polyester acrylate binder containing a photoinitiator and DPGDA reactive diluent. Silica, organically treated silica, amide wax, modified HDPE wax and the new biobased additive were used as matting agents. The coating was applied with a bar applicator to give a dry film with a thickness of 20 µm. There is, however, no equipment for testing haptic properties of coated samples. A number of individuals were asked to evaluate the samples by feeling them. The coating containing the biobased additive was consistently judged as the smoothest and most pleasant, thus the biopolymer additive improves the haptic effect of coatings.
It should also be noted that this improvement does not generate an increase in slip. The CoF (Coefficient of Friction) of the coating is similar with and without the biopolymer. Coating surfaces were examined in more detail using a confocal 3D microscope (“MicroSpy Topo DT” from FRT GmbH). Representative images reveal differences in surface roughness and structure (*Figure 6*).

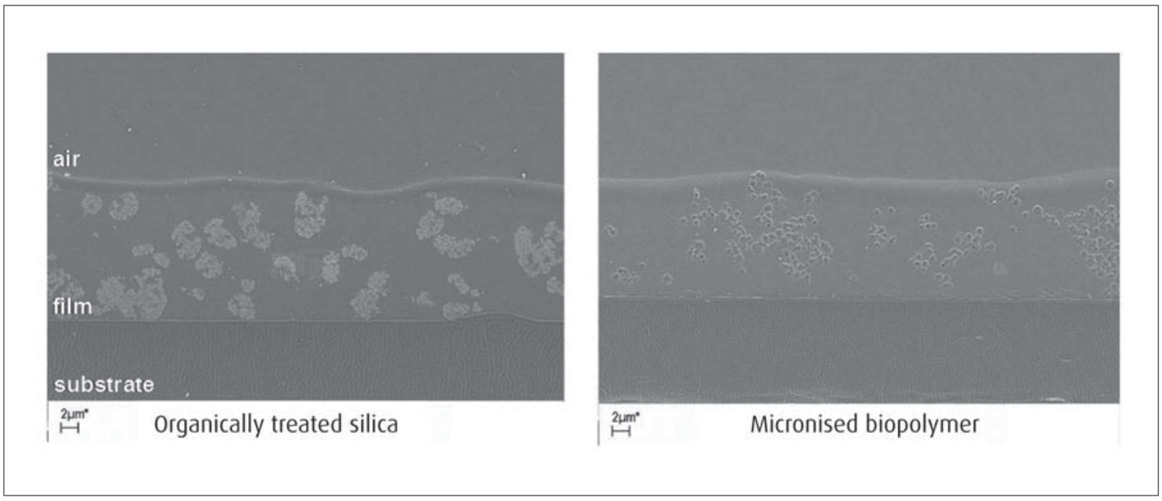


Figure 5: Cross-section SEM images of coatings containing organically treated silica and “Ceraflour 1000”

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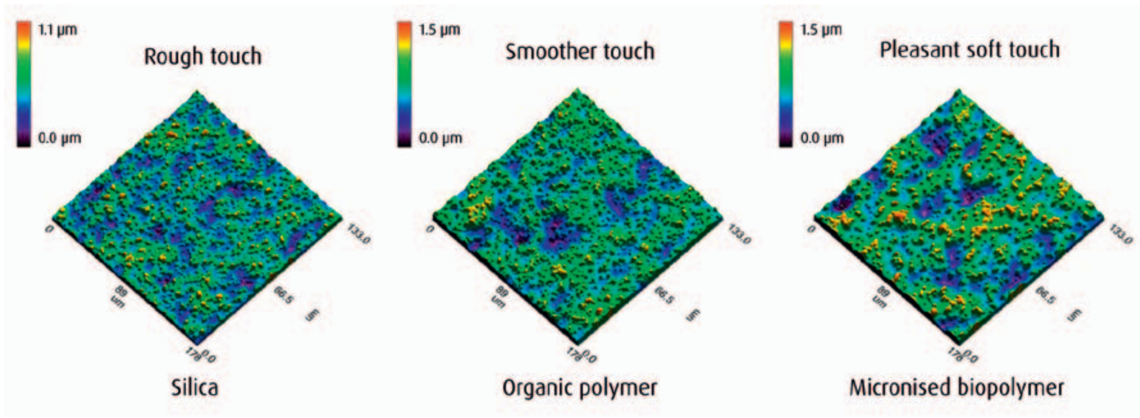

Figure 6: 3D microscopy images of selected coating surfaces

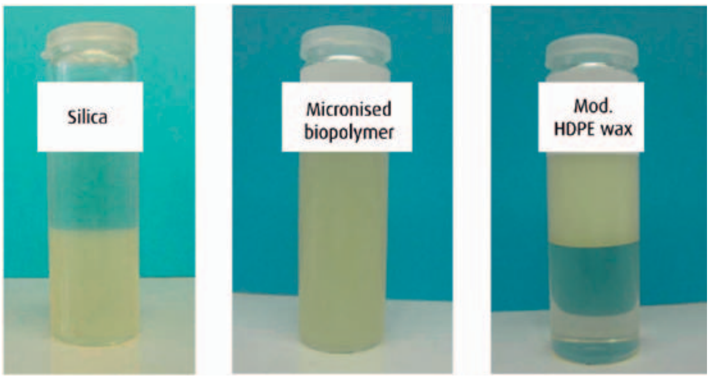

Figure 7: Storage stabilities of three additives in a 100 % solids UV system after four weeks

The coating containing silica, which has the roughest touch, has a regular distribution of fine elevations at the surface. On the other hand, the coating containing the biopolymer based additive, which has the most pleasant touch, is characterised by a regular distribution of coarse elevations.

Storage stability is good

As already indicated above for the polyester acrylate system, the biopolymer based additive is in general easy to incorporate into all types of coating formulations without the formation of dust or stabilisation of foam. Additionally, good storage stability was observed in all types of systems.
For this purpose the biobased additive was added to a coating formulation and stored for four weeks at elevated temperatures. Coatings applied before and after storage produced the same low gloss values, and neither seeds nor hard settlement could be observed. In 100 % UV systems the biopolymer based additive also showed homogeneous in-can distribution, after storage. In comparison, silica tends to settle and wax to cream, as shown for a 100 % urethane acrylate system in *Figure 7*.

Some film properties are also improved

In general, the applied films containing the biopolymer based additive show good levelling. In addition, it is observed that the additive may improve the scratch- and abrasion resistance of a coating. In this respect, the additive was, for example, incorporated into a system based on an acrylate dispersion. The applied films were subjected to different test methods, such as the SATRA rub test or Taber abrasion test.
Regarding the enhancement of the mechanical film properties, the biopolymer based additive performed better than silica and polymer matting agents, but was inferior in comparison to a modified HDPE wax. Combination with HDPE wax is recommended to achieve additional improvement of mechanical resistance. With the biopolymer additive, burnishing or polishing effects and finger marks were not observed.

Benefits throughout the life cycle

An innovative biopolymer based additive with an excellent combination of properties has been developed. The product is based 100 % on renewable resources and is completely biodegradable under normal conditions, for example in landfills, with zero toxic waste as it is ultimately converted into carbon dioxide and water.
The key benefits are excellent matting efficiency, especially in UV systems, combined with high transparency and a warm smooth feel without influence on slip.
Additionally, the additive improves scratch-, abrasion- and blocking resistance. It can be used in solvent-free, solvent- and waterborne systems without detrimental influence on viscosity. Easy incorporation without dust formation and foam stabilisation is combined with good storage stability of the coating systems.

REFERENCE

[1] www.byk.com, Instruments, Byk-Gardner catalogue, or http://www.byk.com/en/support/instruments/downloads/catalog.html.

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