Nanoscale UV-absorber for sustainable paint and coating applications

W. Wessels, U. Nolte, M. Berkei*
*BYK Chemie GmbH, Wesel, Germany, michael.berkei@altanachemie.com

Abstract

In this paper different types of inorganic nanoscale UV-absorbers are described. Such nanoparticles are commercially available in form of dispersions in a variety of different media: Thus, they can be used in different types of coatings and plastics, to enhance the life-time of such polymers.

Keywords: UV-protection, zinc oxide, ceria, nanoparticle, coating

Results

In modern coatings the demand for an enhanced life-time is increasing more and more. The idea of an everlasting surface that keeps its properties unchanged has become the driving force for an ongoing research in this field.
Today, almost all kinds of surfaces are coated. Since polymeric resins suffer from UV-light, the demand for UV-protection is enormous to protect not only the coating, but also the substrate. This can be high class furniture or automobiles as well as traffic signs or even food packaging. Beside the fact that everything should keep its nice looking appearance as long as possible, there is also the need to prevent the material from weathering and destruction.
Degradation of polymer-based coatings from UV light exposure is a widespread problem in the coatings industry. This issue is generally addressed through the use of organic materials specifically designed to absorb UV radiation. Such organic UV-absorber are soluble in the film matrix, and thereby impart no loss of clarity when used in transparent coatings. However, these organic UV absorbers also tend to migrate out of the coating, and undergo UV degradation themselves, limiting their effectiveness over time.
Some inorganic materials such as zinc oxide, ceria and titania are also absorbing UV radiation and could therefore be an interesting alternative to organic UV-absorber. Inorganic materials are particular and do not migrate out of a coating and do not suffer from UV-radiation. Thus, they are perfectly suitable for applications, where a long-time protection is necessary.

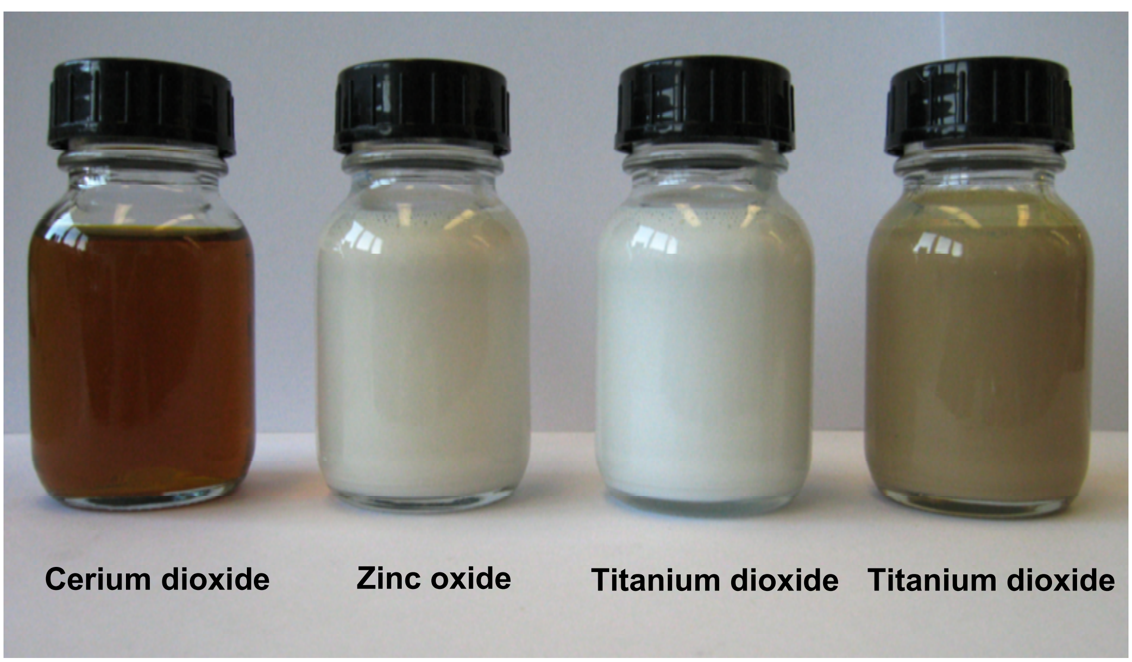

Fig. 1: Dispersions of different nanoparticles in water, exhibiting different colors and grades of transparency

One drawback to use inorganic UV-absorbers is that they contribute significant haze to coatings, even at relatively low dosages. This is due to their high refractive index, compared to those of polymeric resins. As an example, titanium dioxide has a refractive index of about 2.5, while polymers are usually in the range of about 1.5. This large difference in refractive index makes the usage of titanium dioxide for clear coats a challenge.

To minimize the amount of haze, one idea is to use those inorganic materials in form of nanoparticles. For high gloss and transparent systems, nanoparticles offer many advantages compared to larger particles. Depending on the refractive index and morphology of the material, small particles in the range below 50nm are most preferred. Such small particles will not change the optical properties of a coating, depending on the concentration of course. Loading with nanoparticles is quite important for many reasons, because high fillings usually lead to undesired changes in properties.

Many variables influence the transparency of a composite material, including film thickness, filler concentration, particle size, particle shape, extent of particle aggregation, homogeneity of the particle dispersion, and the difference in refractive index between the bulk coating and the filler particle. Figure 2 shows transmission spectra for different nanoparticles included in a 50µm clear coat.

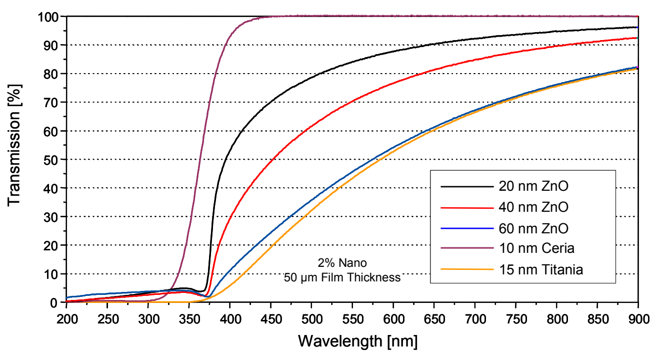

Figure 2: Transmission spectra of different nanoparticles dispersed in 50µm clear coat film.

As can be seen, optical transparency of nanoparticle dispersions depends heavily on the mean particle size of the nanoparticles and its refractive index. The effect of particle size on performance is clear by comparing the UV and visible spectra of zinc oxide at three different mean particle sizes (20, 40, and 60 nm). As the mean particle size decreases from 60 nm to 20 nm, UV absorbance does not change but light scattering in the visible region is significantly diminished.

The recent availability of nano-scale inorganic fillers enables the use of these materials in coatings in which clarity is an important property. Based on this, a series of inorganic oxides having a mean particle size less than 100 nm were evaluated for their suitability in providing UV protection to coatings, as well as their impact on optical transparency of the system.

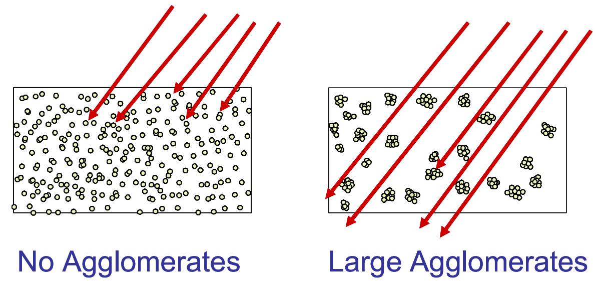

Figure 3: Importance of well dispersed nanoparticles to maximise the performance.

The performance of a metal oxide nanoparticle with respect to UV protection of transparent coatings depends not only on its efficiency of absorption across the ultraviolet region, but also on its distribution inside the coating. While most organic UV-absorbers are molecules soluble in different solvents, inorganic UV-absorbers are used in form of particles. Such particles need to be dispersed into a solvent and stabilised against agglomeration. To ensure a good distribution of material, the particles need to be small as well as good dispersed. Otherwise, large agglomerates are formed and the benefit from nanotechnology is lost (figure 3).

Like any other organic compounds even organic UV-absorber suffer from UV-radiation. This effect results in poor long-time stability, when exposed to UV radiation for a long period of time. Figure 4 shows the change in colour over time for mahagony wood panels weathered with UV-B light. The panels were coated with a transparent clear coat based on resin LUX 399 at a film thickness of 50µm.

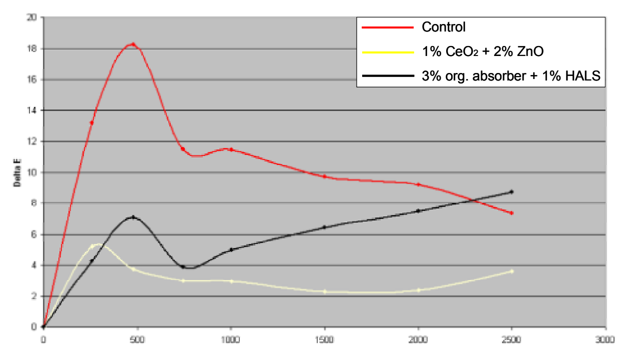

Figure 4: Delta E values for coatings using different UV-absorber

This example demonstrates the difference in long-time performance between an inorganic UV absorber compared to an organic one. While the inorganic material keeps a very low degree of discolouration for at least 2500hrs, the organic UV absorber starts to fail after 1000hrs. It becomes obvious how tailor made nanoparticles will change the performance of modern coatings.

NSTI-Nanotech 2009, www.nsti.org, ISBN 978-1-4398-1784-1 Vol. 3, 2009