The Pigment Industry – An old-established industry between classic pigments and nanotechnological products

The economic importance of the pigment and filler industry

Some 100 companies in Europe produce pigments and fillers in synthetic processes. Around 75% of these businesses are small and mid-sized enterprises. With roughly 23,000 staff, they achieve sales of ca. 8.1 billion euros. Germany is a major production location and an important market for pigments and fillers.

What are classic pigments and fillers, and where are they used?

Classic pigments are substances which consist of solid particles and are insoluble in the application medium, as described in the definitions of standard DIN EN 55943. Standard DIN 55944 lists pigments according to colouristic and chemical aspects. Pigment applications demand properties such as e.g. dispersibility, colour strength, light and weather fastness, migration resistance, colour shade and hiding power. These properties depend both on the chemical composition of pigments and on the size and morphology of particles.

Fillers are used primarily for their technical properties and less for their colouristic characteristics. Given the technical requirements, such fillers must be dispersed homogeneously in the application medium. They are mostly very finely divided, solid substances. Pigments and fillers are optimized for specific application conditions, often by way of mechanical and chemical surface treatment. The thickness of such layers on pigment surfaces is determined exclusively by the sought technical properties.

Pigments and fillers are used for colouring and filling purposes in coatings, decorative and protective paints for buildings and machinery, plastics, printing inks, ceramics, candles, paper products, pharmaceuticals, rubber materials, abrasives, soaps, textile fibers, foodstuffs, decorative cosmetics, sunscreens, toys, road signs, safety technology equipment and cement. Many more examples can be provided.

What does nanotechnology mean?

Nanotechnology is a technology of the future – with great potential for new applications. Chemical, physical and biological substance properties of particles and structures, which do not materialize in macroscopic objects of the same composition, can be brought about in the nanometer range.

Almost all objects in our natural environment have nanostructures. Where such nanostructures enable special properties, we try to imitate them. Many pigments and fillers - which are omnipresent around us – present nanostructures.

In nanotechnology, nanoparticles are produced – in a targeted manner – with a particle size distribution between 1 and 100 nm, in order to achieve the sought properties. By contrast, classic pigments and fillers have a potential particle size distribution between 50 and 50,000 nm. They contain no significant shares of free nanoparticles.

Pigment-specific definitions are given in DIN 55943. At the level of ISO, materials science experts developed a technical specification (DIN CEN ISO/TS 27687). They aimed to elaborate uniform definitions from the scientific viewpoint. However, these definitions are not intended for regulatory purposes.

This technical specification clearly shows that "nano" is seen as an indication of size. But in many cases it is not obvious to consumers what exactly "nano" is supposed to mean for one product or another. Due to the large number of new terms, this technical specification is difficult to communicate.

Moreover, finished products do not necessarily contain "nano" if this was previously consumed in a chemical reaction of intermediates.

For these reasons, most producers of pigments and fillers take a highly differentiated view of the prefix "nano".

Nanoscale systems with pigments and fillers

Pigments and fillers are found in all articles of modern living, which would be inconceivable without these substances. Pigments and fillers have technical, decorative, protective and safety-related functions. Colour effects of articles are of great importance and influence the purchase decisions of consumers.

The pigment and filler industry has always been striving to improve application technology properties. Classic pigments and fillers are available with more or less wide particle size distributions in the micrometer range and with different morphologies. Nanoscale systems can be created in dispersion processes in application media (such as e.g. paints, coatings or plastics) - depending on the shear force and the morphology or particle size distribution of starting materials. This opens new chances in the marketplace and enables new or improved use properties for consumers.

Some examples of nanoscale systems

- High-performance sun screens are essential, both on beaches and in high mountain areas. As consumers are unlikely to paint themselves white, sunscreen products should preferably be invisible, while offering the best possible level of protection. This is achieved with nanoscale dispersed, inorganic "UV filters" in sunscreens.

- Relatively large metal or mica pigments give a metallic or glittering appearance to effect coatings. The colour range of effect pigments is limited; it is not possible to produce all colourful metallic or effect coatings with effect pigments alone. The very fine dispersion of pigments in coatings makes all colours available.

- Top coats of motorcars or parquet floorings are meant to be shiny. Therefore, they should be as scratch-resistant as possible and not age under the impacts of light or weather. Nanoscale dispersed, inorganic fillers and pigments considerably improve both scratch-resistance and UV protection of such top coats. The properties "scratch-resistant" and "light-resistant" are system properties of coatings; thus they are part of purchase decisions of consumers.

- Obviously, adhesives must offer good adhesive properties. But they also need to have some consistency, or they would simply 'run'. With the conventional possibilities of polymer chemists, these two conflicting properties cannot be optimized independently from each other. Now their optimization is feasible by producing dispersions, which contain tiny plastic pellets in sizes of some hundred nanometers and additionally nanoscale organic or inorganic particles in sizes of 10 to 20 nanometers.

- Aqueous polymer dispersions are another way of endowing conventional substances with new properties. For example, they are used in wall paints where a new generation of binders renders façades highly resistant to weather and dirt – by forming nanostructures. The principle: Inorganic nanoparticles are incorporated and fixed in organic polymer pellets of aqueous dispersions. After application and drying of the paint product, the inorganic nanoparticles form a homogeneous, tridimensional network. This network repels dirt and prolongs the lifespan of paint.

- Some surface coatings contain a photocatalytically active, nanoscale dispersed semiconductor substance. In these surface coatings, the UV share of sunlight triggers a degradation process of organic dirt or pollutants.

Consumer protection and occupational health and safety in the pigment and filler industry

Usually consumers come into contact with pigments and fillers only where products are coated and/or coloured with them. In such products, nanoscale dispersed particles are firmly bound in a matrix or in a liquid preparation.

Handling and use of chemical substances in the pigment producing and processing industry are adequately regulated by several pieces of legislation. Control measuring ensures compliance with legal requirements. As an additional step, the German Chemical Industry Association (VCI) and the Federal Institute for Occupational Safety and Health (BAuA) jointly published in 2007 the "Guidance for Handling and Use of Nanomaterials at the Workplace".

Particle size distributions in pigments and fillers are always product-specific. Consequently, a certain coarse share and a certain fine share are present in all pigments and fillers. The fine share consists of aggregates and agglomerates in the micrometer range. These can have highly specific surfaces, depending on the material. Nanoparticles (in all three dimensions under 100 nm) have not been detected in significant quantities in pigments and fillers.

Toxicological studies – on which information in safety data sheets relies – are always carried out using dispersed pigments, including the nanoparticulate share which they might contain. Therefore, thus obtained toxicological results invariably include the impacts of aggregated nanomaterials, which can be present in pigments or fillers. Consequently, a potential toxicological risk is covered.

The production of finely divided pigments and fillers takes place in industrial-scale plants, where all aspects of occupational health and safety and environmental protection are reliably met. Measuring results show that the particle concentration in the nanoscale range inside production plants is not significantly higher than it is in outside air. Consequently, no extra burdens on humans and the environment are identified. Filters are state-of-the-art in exhaustion and decanting processes.

In downstream uses – e.g. in coatings production – the individual constituents are mostly added automatically. In coating products, pigments and fillers are surrounded by the liquid matrix. For this reason, emissions of finely divided substances can occur only in decanting – where, however, they are prevented by filters. Regarding the application of automotive coatings in industrial plants, existing laws minimize emissions for workers and the environment. Studies of finished coatings substantiate that abrasion does not cause any extra burden on the environment through nanoscale pigment and filler particles.

Publications on consumer protection and occupational health and safety

The pigment industry is committed to the "Responsible Care" initiative of the chemical industry. Thus the pigment industry is fully aware of its responsibility for workers, processors, consumers and the environment.

In 1995 the pigment and filler industry took a new path by publishing the brochure "Safe Handling of Pigments". This brochure was listed as a "guidance document" at the 2nd International Forum of Chemical Safety in 1996. The publication "Safe Handling of Pigments" came out in the languages German, English, French, Spanish, Portuguese and Chinese.

In a comparable manner, the brochure "Ceramic Decorating Materials" covered the safe handling of products for the ceramic industry. This brochure was published in the languages German, English, Spanish and Italian.

In the brochure "Colourants for Food Contact Plastics" the pigment and filler industry provides information about the safe use of its products for plastic materials in contact with foodstuffs. This brochure is available in German and English language.

The above brochures were published by the following industry associations:

- ANFFECC (Spain)
- BCMA (UK)
- Ceramicolor (Italy)
- EPSOM (France)
- ETAD (Switzerland)
- VdMi (Germany)
- Eurocolour (Europe)

The VdMi position paper "Inorganic pigments under REACH" lists a number of inorganic pigments by way of example*.

The pigment and filler industry is dedicated to the responsibility of the entire chemical industry – namely to provide products which are safe for humans and the environment.

* http://www.vdmi.de/files/Anorganische_Pigmente_unter_REACH.pdf

Nanotechnology in marketing

For marketing reasons, over the past few years some companies actively chose the prefix "nano" for newly developed, finely divided pigments and fillers and for relevant new applications. Today "nano" often stands as a synonym for "progressive" – comparable to how "2000" was used in advertising before the turn of the millennium.

According to a report by the German Federal Institute for Risk Assessment (BfR) on the perception of nanotechnology in the general public ("Wahrnehmung der Nanotechnologie in der Bevölkerung") most consumers associate the term "nano" with something "miniaturized, progressive and modern". Here, the term "nano" is not specifically focused on the dimension "10 to the minus 9" – it is becoming a dimensionless term such as e.g. "mega" (Megapearls® or "mega events" make good examples). This is also strongly reflected in the designation "iPod®" or in the name of the compact car "Nano" from India.

The future will tell about the market potential of nanotechnology.