FreeNano - Test Methods for Release of Pigment-Nanoparticles Into the Environment at the End of Life Cycle

M. Stintz and D. Göhler

Research Group Mechanical Process Engineering,
Institute of Process Engineering and Environmental Technology,
Technische Universitaet Dresden (TUD),
D-01062 Dresden, Germany, michael.stintz@tu-dresden.de

ABSTRACT

Several coatings with and without nanoscaled additives and pigments were exposed to artificial aging and weathering, before they experienced a mechanical treatment by sanding with process parameters similar to professional sanding condition.

The miniature sanding test setup was built up in a particle free environment for the quantification of the potential nanoparticle release into air. The released particles were moved by a defined air flow to a fast mobility particle sizer and other aerosol measurement equipment to enable the calculation of a specific particle release rate additionally to the particle size distribution.

First results on artificially UV-light aged and moisture and temperature weathered surface coatings show an increase of the nanoparticle release, possibly caused by embrittlement of the matrix material, since no free nanoscaled pigments were observed during TEM analyses.

Keywords: nanoparticle, nano-object, release, pigment, surface coating

1 SCOPE

Nanoparticle additives and nanoscaled pigments are increasingly used in surface coatings and composite materials to achieve customized product properties. Uncertainties concerning possible hazard to health safety and environment necessitate investigations according to their release into the air.

Exposure studies in laboratory as a consequence of the tiered approach of exposure measurements in workplaces [1] can provide basic data about the ability and/or the quantity of nanoparticle release from engineered nanostructured material due to the simulation of suitable treatment processes. Based on the results of such investigations it may be possible to estimate the potential risk to health, safety and environment and/or to define nanoparticle-dosage for toxicological considerations.

2 LITERATURE OVERVIEW

Currently, only few studies analyzed the release of engineered nanoparticles (< 100 nm) and nano-rods and nano-plates with one or two dimensions larger than 100 nm, which are summarized as nano-objects (ENO), from composites and coatings in the air. Vorbau et al. [2], Guiot el al. [3] and Wohlleben et al. [4] examined weak, but long-term abrasion processes and found only a slight release of coarse particles containing embedded ENO. Total abrasion by sunlight, wind and human contact [5] led to similar results. The nanoparticle release from coatings due to sanding were studied by Göhler et al. [6], Koponen et al. [7] and Wohlleben et al. [4], while cutting and drill processes on composite material were simulated by Bello et al. [8] and [9]. Sanding, cutting and drilling based on high energy input, that led in each case to a considerable generation of nanoparticles, whether ENO were added to the matrix material or not. Free ENO were only observed by Bello et al. [9], which might be explained by thermal degradation of the matrix material.

Coatings are subjected during their life-cycle, i.e. from the production, the processing over the use and weathering until recycling, to different treatment processes. External impacts like sunlight, moisture or temperature fluctuations can destruct the matrix material that could lead to an open laying of embedded pigments and additives and is probably associated with a higher release risk as shown by Kaegi et al. [10] for the transition of TiO2 from facades in the aquatic environment. Apart from Wohlleben et al. [4], no study has reported the possible nanoparticle release of samples with partially or completely degenerated matrix material.

3 RELEASE TEST METHOD

Based on the analysis method presented by Göhler et al. [6] numerous coatings with and without nanoscaled additives and pigments were exposed to artificial aging (according to EN 927, dry), before they experienced a mechanical treatment by sanding. The employed sanding process parameters in the laboratory were chosen similar to professional sanding condition.

The findings on the particle release of the investigations can be summarized as followed. The applied aging conditions of the analyzed coatings were accompanied with a change in the particle size distribution of the swarf aerosol and led to a significant increase in the total particle number release (< 10 µm) and in the nanoparticle number release (<

100 nm). During all investigations no free nanoscaled additives or pigments were observed in the electrostatically-precipitated swarf aerosol by scanning electron microscopy, transmission electron microscopy (see Figure 1) and energy dispersive X-ray spectroscopy. Hence the nanoparticles, released into air, originated from the matrix material of the coatings. Furthermore, no systematic impact on the number of released nanoparticles was observed by the comparison between the doped and the un-doped samples, i.e. some additives or pigments show an increase, whereas others show a decrease.

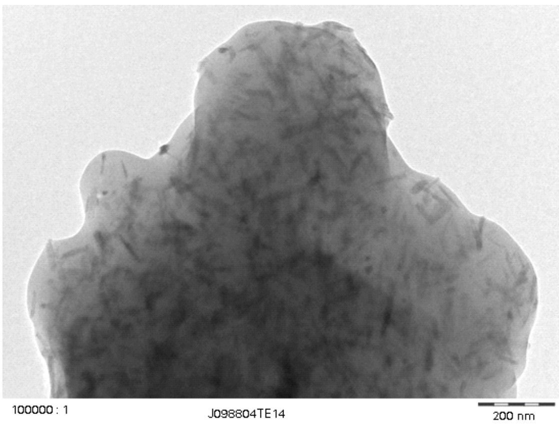

Figure 1: TEM-image of an electrostatically precipitated acrylate varnish swarf particle with firmly embedded ferric oxide nano-objects (bar length 200 nm)

Results of further studies confirm the suitability of the method for the quantification of the nanoparticles release into the air from synthetic nano-composites. Thus, the method can also be used for future studies on coatings and composites containing other nano-objects, e.g. carbon nano-tubes. Due to the wide applicability of the method and the possibility of systematic analysis with sufficient repeatability, standardization is sought.

4 ENDNOTES

The wording and definitions used in this abstract base on ISO/TS 27687:2008 and ISO/TS 80004-4:2011.

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