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ADVANCER

FRAUNHOFER HIGH-PERFORMANCE CERAMICS ALLIANCE

advancer®
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The name "AdvanCer" conveys a sense of foresight, progress and benefit. Ceramics manufacturers and users find in it their "Advanced Ceramics" materials holding great promise for the future. AdvanCer presents innovative applications for high-performance ceramics: systems solutions with "Ceramics inside" for today and tomorrow.

CONTENT

NANOTECHNOLOGY – GREAT POTENTIAL WHEN SECURELY HANDLED

With decreasing particle sizes great hopes are placed in improved product properties, and thus in new applications in fields such as energy and medical technology, automotive and electronics.

Examples include surface coatings which are scratch-resistant and easy to clean, high-gloss paints, super-hard materials, antimicrobially functionalized textiles or catalysts. At the same time researchers and users are faced with new challenges: On the one side they try to realize the full potential of nanotechnology and on the other side, they have to detect and control possible risks which may be connected with the nanoscalability of the material.

LUMiSizer® for analysis of suspensions (stability, particle size distribution).

For a safe handling of nanomaterials and nanotechnologies the entire life cycle of particles has to be studied, from synthesis to disposal or recycling. Research on effects of nanomaterials is summarized as "nano-toxicology" where the focus is on nano-objects, i.e. on materials which are at least one geometric dimension smaller than 100 nm. Materials and natural scientists, human toxicologists and ecotoxicologists as well as biologists and medics together evaluate the effect of nanomaterials.

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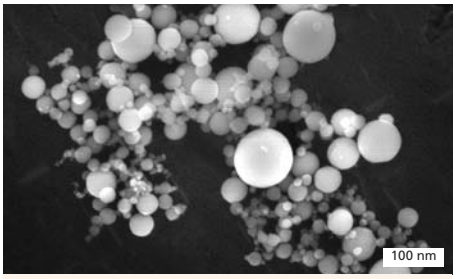
All evaluation and interpretation of toxicological data starts with the exact knowledge of the material properties determined by the production or synthesis process. Technical nanoparticles such as silica or TiO_2 are often available in form of aggregate powders. That means that the nanoscale primary particles are linked to each other through material bridges resulting in larger units – aggregates.

To be used in some applications like in dispersion layers the primary particles have to be isolated from each other. In order to largely prevent aggregation during the production process, the materials are prepared by a wet chemical process and offered in form of suspensions containing, in addition to particles and fluid, dispersants of different chemical composition in order to stabilize the primary particles. For this reason, the particle surfaces are coated and the material properties are not only determined by the composition of the nanoscale base material but also by the coating.

After the nanomaterials have been analyzed in the as-delivered condition in terms of chemical composition, specific surface, density, primary particle size and physical state, the particle behavior in an environment which is relevant for toxicological



FESEM picture of a nanoscaled Al_2O_3 powder.

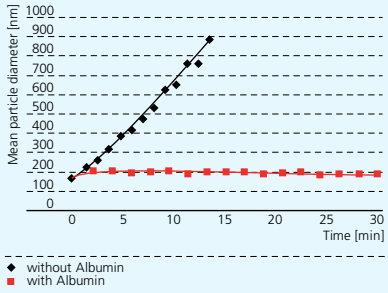
tests is studied. The particle properties in the test medium – air for inhalation tests, physiological fluids for in-vitro tests, and salt solutions for ecotoxicological tests – are mainly determined by the kind of the dispersion state that the particles have before they are added to the test medium. In order to compare the results of different tests, international standards have to be implemented.

The dispersion determines whether the nanomaterials occur in form of primary particles or aggregates or in form of agglomerates, i.e. in units that can be destroyed by energy input. As size and specific surface are parameters that influence the incorporation of particles in the organism their analysis has to be especially considered. In liquids the surface charge properties are characterized to measure the tendency to agglomerate. If there is an electrostatic repulsion between two particles or aggregates, i.e. the zeta potential is high, agglomeration is effectively prevented.

For toxicological tests complex physiological media are of relevance which are characterized by a high salt concentration and thus high conductivity. In these solutions the compression of the electrochemical double layer around the particles is so strong that agglomeration occurs within just a few minutes. The agglomeration rate depends on the primary particle size, the solubility, the concentration as well as the composition of the medium. The solubility of the particles in liquids has to be analyzed as ions in solution (e.g. Co^{2+} from WC-Co or Zn^{2+} from ZnO) may determine the toxicological effect of the entire system.

If proteins such as albumin, which is a main constituent in blood, are added to the media the particles work as dispersants. Agglomeration is mainly or completely prevented over several hours or days. Proteins adsorb on the particle surfaces resulting in a steric stabilization. Electrokinetic measurements showed that these particles have the same surface charge like free particles.

In-vitro and in-vivo studies with technical nanomaterials have already been carried out by several research groups. The results, however, published for different nanomaterials, are partly contradictory as it was shown, e.g., in a study of Frost & Sullivan in 2009. It is for sure that nanoparticles are adsorbed by the human body through different paths, but particularly through the lung. It was also shown that nanoparticles may enter in cells but do not necessarily cause toxic effects. It is disadvantageous that present studies generally evaluate short-time effects. Long-term studies are not available up to now.



Agglomeration of TiO_2 particles in PBS depending on the presence of albumin.

Ecotoxicological analyses are carried out in less complex media with significantly lower salt concentrations. The evaluations are only just beginning. It was shown, e.g., that nanoparticles may be washed out of colors and enter into the environment. Present studies refer to the effect of nanomaterials that get into waste water treatment plants through the waste water.

In summary it may be said that all efforts are made to realize the full potential of this innovative technology and simultaneously to evaluate the possible risks.

SUCCESS STORIES

ZEOLITE® DRYING SYSTEM PROTECTS THE ENVIRONMENT AND SAVES ENERGY

Up to now, zeolite is mainly known as balls in small packages which are added to new clothes as it has the ability to store moisture and simultaneously release dry air. Engineers at BSH Bosch und Siemens Hausgeräte GmbH made use of this effect and developed the innovative zeolite® drying system for dishwashers having an enormous advantage for the environment: dishwashers with zeolite need 30 percent less electricity than the best dishwashers in their class, making dishwashers with zeolite technology the most energy-efficient in the world.

The drying system works as follows: within the dishwasher's floor tray a container with around one kilogram of zeolite minerals ensures that the dishes are dried after the cleaning cycle by absorbing the moisture from the air in the dishwasher's interior. During the next cleaning cycle, the zeolite is heated up and the moisture released so that it is ready for the next drying cycle.

Zeolite balls help to reduce power consumption in dishwashers of BSH Bosch und Siemens Hausgeräte by up to 30 percent.

In February, this green innovation from BSH was awarded with the "Innovation Prize for Climate and Environment" from Dr. Norbert Röttgen, the German Federal Minister for the Environment. The following calculation shows the contribution to climate protection: If all the dishwashers in use in households today that are over ten years old and use more than 1.3 kWh of electricity per cycle were to be replaced with highly efficient appliances featuring the zeolite drying system, over 1.3 million tons of CO_2 could

Michael Rosenbauer, chief developer for dishwashers at BSH Bosch und Siemens Hausgeräte GmbH.

be saved every year in Germany alone. This is equivalent to the emissions of approximately 600,000 automobiles that drive around 15,000 kilometers a year.

BSH Bosch und Siemens Hausgeräte GmbH is a joint venture between Robert Bosch GmbH and Siemens AG.

CERAMIC MEMBRANES PROVIDE EXCELLENT SOUND

Loudspeaker membranes made of ultrahard ceramics have a particularly pure sound and have been used in high-end and studio sound systems for a long time. In a complex production process Thiel & Partner GmbH manufactures loudspeaker membranes made of alumina. There, a thin aluminum tape is shaped by deep drawing, completely oxidized in a proprietary process and changed to alpha corundum in a special firing process. At the end of the process a snow-white and extremely hard membrane is available.

There are various requirements on loudspeaker membranes: The membrane has to be light, stiff and highly damped. As these requirements contradict each other in terms of design the use of all conventional membrane materials is full of compromises. The material developed by Thiel & Partner meets all three requirements without compromises. The right selection and proper processing of the aluminum tape allows for extremely thin (up to smaller 50 µm), and thus very light components. Due to the material's extreme hardness (Mohs' hardness 9) dimensionally stable membranes can be realized.

The comparatively high inner damping of the Thiel & Partner ceramic membrane is guaranteed by the specific production process. As the oxidation proceeds from both sides to the membrane middle an interface develops consisting of two interlocked membranes damping each other. Moreover, the mentioned pore formation results in additional transverse interfaces. The foam-like microstructure of the ceramic membrane has a considerably better inner

ACCUTON® midrange toner with ceramic membrane.

damping leading to a better impulse response and a significantly reduced distortion as compared to conventional materials as well as a broader bandwidth of the linearly transmitted frequencies.

Thiel & Partner GmbH, whose product portfolio includes 25 different loudspeaker chassis with membranes of corundum and diamond, distributes its ACCUTON® ceramic drivers to many of the leading speaker designers of the high-end world.

Adrian Bankewitz, CEO of Thiel & Partner GmbH.

IMPORTANT DATES

AdvanCer training courses
"Advanced ceramic materials"

- Part 1: Materials, technologies
  March 9 and 10, 2011 (Dresden)
- Part 2: Machining
  May 4 and 5, 2011 (Berlin)

For further information please see
www.advancer.fraunhofer.de

- DKG expert committee on material applications »Ceramics in measurement and analysis technology at high temperatures«
  February 23, 2011 (Selb)
- Symposium »Nanotechnology and Toxicology in Environment and Health«
  April 11 and 12, 2011 (Leipzig)

For further information please see
www.dkg.de and www.ufz.de

NEWS

FRAUNHOFER TALENT SCHOOL

In early November, 30 talented young persons interested in technology visited the Fraunhofer Talent School in Dresden. There, they got to know what current research deals with and which methods are used to research and develop new technologies. The three-day seminar focused on project work in workshops on various scientific topics. Scientists at Fraunhofer FEP, IKTS and IPMS imparted the necessary theoretical basics and were available for discussion. At Fraunhofer IKTS the students learned in exciting experiments, how different kinds of fuel cells work, where they can be used and then built their own fuel cell. In the evening Fraunhofer management personnel as well as figures from politics and industry gave an insight into the everyday life of researchers as well as into national and international academic life.

The Fraunhofer-Gesellschaft, Germany's leading application-oriented research organization, early wants to get in touch with its researchers of tomorrow. "With Fraunhofer Talent School we invest in the young generation. We early develop and challenge the young generation. In a country without natural resources the intellectual curiosity of our children is the best asset!" said Prof. Hans-Jörg Bullinger, president of the Fraunhofer-Gesellschaft. In 2010, Fraunhofer Talent School took place at thirteen different Fraunhofer sites.

FUTURE NEEDS IDEAS

According to the motto "Future needs ideas" the member institutes of the Fraunhofer Additive Manufacturing Alliance present themselves at this year's EuroMold trade fair in Frankfurt. From December 1 to 4, the Fraunhofer IKTS shows solutions for the development of ceramic materials and innovative manufacturing methods on the joint booth in hall 11 (booth D66). A 3D ceramic printer, by means of which complex ceramic components such as hydroxyapatite for bioactive implants can be built up, is one highlight of the exhibition. Furthermore, Fraunhofer IKTS presents ceramic wear-resistant tools and dies as well as its results on contour machining of ceramic prototypes such as springs and threads.

Another highlight is the bionic handling assistant which was developed by FESTO and Fraunhofer IPA in a joint project. Drawing on the fundamentals of bionics, the researchers transferred natural construction principles to a robotic system, creating a unique handling system that achieves humanoid lightness of touch, dexterity, and flexibility. For this development both project partners are nominated for the German Future Prize which will be awarded on December 1, 2010.

EDITORIAL NOTES

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