Nanomaterials at the workplace

Stakeholder dialog on industrial health and safety

Frankfurt am Main, 26 September 2005

Dialog Documentation

Mainzer Landstraße 55
60329 Frankfurt

Postfach 11 19 43
60054 Frankfurt

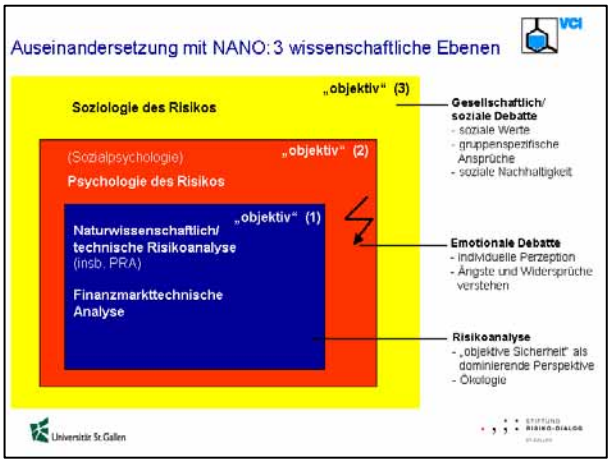
Telefon +49 69 2556 - 0
Telefax +49 69 2556 - 1471

I. Executive Summary

Background of the event: (Dr Gerd Romanowski, VCI)
Nanomaterials offer fascinating possibilities of application and promise great potential in innovation and markets. Besides the USA and Japan, Germany ranks among the leading competitors worldwide, both scientifically and economically. In order to be sustainable, innovations must be safe for humans and the environment. Therefore, VCI is committed to safety research at national and international levels. Additionally, VCI has initiated a series of dialog events on industrial health and safety, environmental protection and consumer protection/product safety. The foundation Stiftung Risiko-Dialog develops a concept and moderates the neutral stakeholder dialogs, which are intended to jointly build knowledge and to identify knowledge gaps. For this purpose, intensive preparatory interviews were held with all groups. The goal of three VCI dialogs is to concretize the joint next steps and to work in a result-oriented manner. Participants in the stakeholder dialog on industrial health and safety are occupational health and safety experts, toxicologists and physicians from:

- Public authorities / ministries
- Science
- Trade unions
- Employers' liability insurance associations (Berufsgenossenschaften)
- Environmental organizations
- Industry (manufacturers and users)

Stakeholders in dialog: (Prof Dr Matthias Haller, Stiftung Risiko-Dialog)
The lecture focuses on the 3-level model of risk communication. Typically, science and industry argue at the natural science-technical level (blue) in the nanotechnology debate. It is tried to address hopes and fears (red level) that can be brought in a psychologically objective form, or sociological values (yellow level) with more scientific-technical information (blue level). However, the assessment of risks at psychological and social levels is decisive for the trust in institutions and the responsible handling of risks. According to Haller/Grobe, the assigning of a risk issue to a specific risk class is of major importance, too. If an assignment is made to the class of accident risks, an accident is deemed a risk.



If nanotechnology is seen as a system risk – where risks are generated even in normal operations – rather the fundamental question arises if this technology is desirable and within which limits (limit values). If this is about a risk for the future, the question of how chances are perceived is the real conflict, given an insufficient data situation. Currently all three types of risk are being discussed for nanotechnology. They must be considered in the dialog, just like the three levels of risk communication.

Are nanomaterials dangerous? (Prof Dr Harald Krug, Forschungszentrum Karlsruhe)
Starting point for this lecture is the estimate by Rice University that, in the next five to ten years, the global production of nanomaterials will increase considerably. Exposure of humans will rise. However, general statements on the toxicity of nanomaterials are difficult to make, because there are large differences in the behavior of these materials. A differentiated view is necessary. Generally, toxicologists are working on the identification of the hazard potential, they are estimating quantitative hazards and exposure, and they are developing a risk characterization. Well covered are e.g. research on titanium dioxide by Pflücker et. al. (2001) on skin penetration, dependence between particle surface and intensity of inflammatory lung reaction by Oberdörfer (2001), and again respirability by Gehr and Knapp et. al. (2004). Preining (1998) made statements on the agglomeration behavior of TiO_2.

The data situation is comparably good for SiO_2 and carbon nanotubes. Furthermore, Krug points to studies of nickel and gold, in order to outline – from a toxicological perspective – substances used in industry and research. He stresses that some of the studies must be treated with caution, because there are contradictory findings for which no explanation model is available as yet, or partly very high doses far removed from real conditions had to be used in experiments. Krug summarizes that it is currently difficult to estimate early any health impairments caused by nanomaterials, because no sufficient information is available on exposure at the workplace and in the environment. The goal must be to detect toxicologically relevant effects of nanomaterials at an early stage and to reduce possibly existing risks of nanosciences and nanotechnologies, to an acceptable level.

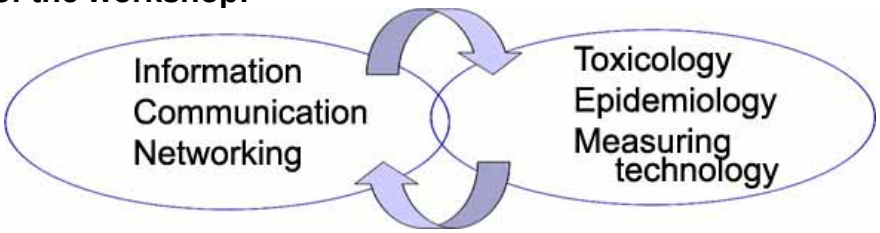
Nanomaterials at the workplace (Dr Antje Grobe, Stiftung Risiko-Dialog)
The background of the dialog is a (still) positive perception of nanotechnology in the general public and in the media. At present, the media are focusing on innovative applications or outstanding researchers (media analysis of Stiftung Risikodialog, 2005).

However, stakeholder interviews lead to expect that the publication of risk studies and reports on citizens' conferences will result in an increase in negative reporting in 2005/06. Moreover, a shift in issues is likely – to questions of food safety and consumer protection, agriculture and the military use of nanomaterials.

Antje Grobe takes up questions, priorities and suggestions from stakeholders, as they were mentioned in the preparatory interviews regarding industrial health and safety. The goal of the workshop is to build – jointly between stakeholders – more knowledge on toxicity, epidemiology and measuring technology. Another goal is to improve information, communication and networking.

The following focal subjects were outlined in the preliminary talks and brought in a more precise form in the plenary in the morning:

Structure of the workshop:



Structures

- Definition of nanoparticles
- Approach to "not knowing"
- Survey on manufacture and use
- Data gathering
- Communication of "best practice" for occupational health and safety

Contents / Data

- Toxicological potential
- Measuring technology
- Classification
- Epidemiology
- Safety data sheets / protection measures

Workshop results: Information, communication, networking

Definition:

- The group sees the need to differentiate by size (< 100 nm and extended range up to 500 nm for agglomerated particles), morphology, chemical composition, agglomeration behavior and bioavailability. This extension brings advantages, because in many companies there are, in production processes, no nanomaterials of < 100 nm (agglomeration); otherwise, those lacking materials would not be reflected.
- The differentiation between nanoparticles occurring in nature and nanoparticles manufactured targetedly by industry is deemed useful.

- **Further steps: National and international standardization activities are to be intensified. NGOs should become involved.**

Data gathering on site:

Core questions to be asked:

- What is manufactured? What quantities? Which processes are used? Are systems closed? (interface plant-man, filter, disposal)
- What exposure is there? Which protection measures are in place?
- How can aggregated data be gathered without revealing business secrets? Anonymization is necessary.
- Substance-specific data gathering is necessary: Agglomeration and modeling of the decomposition of agglomerates must be centrally taken into account.

- **Further steps:**

Agreement between industry and public authority on a questionnaire survey among VCI member companies, regarding exposure and industrial health and safety measures:

- **Questions are formulated jointly by the Federal Institute for Occupational Safety and Health (BAuA) and VCI**
- **Anonymization of member companies by VCI**
- **Evaluation BAuA**
- **Open: Inclusion of start-up companies and science**
- **Open: Consideration of aspects of anti-trust law**
- **Aim: Improving the exchange of information betweens stakeholders and improving the data situation**

Code of good practice:

- Three starting points are to be combined with each other: Survey, prevention and communication. Here, it must be ensured that also knowledge gaps are dealt with responsibly.
- Issues of industrial hygiene are discussed in a VCI working group. Guidance is to be developed, together with public authorities.

- **Further steps:**
- **Merging of activities in expert committees**
- **Systematic involvement in the dialog of the various stakeholders**
- **Intensify external communication**

Workshop results: Toxicology, epidemiology and networking

Toxic potential

- Toxicological studies on various nanomaterials are discussed.
- Striven for is a harmonization of methods and measures as well as a closer cooperation between the stakeholders, in order to ensure practicability and relevance of experiments.
- Examination of intake routes: The focus on respiratory organs will be weighted similarly, also in future. But the group pleads to additionally include skin, gastro-intestinal tract, eye, nose and the possibility of reaching the placenta.
- Definition of endpoints: The group discusses effects regarding blood-brain barrier, cardiovascular system, alveoli inflammations and autoimmuno diseases.
- Discussed is the recommendation by NGOs regarding individual examinations (analysis of toxic potential for each individual substance in the various size ranges).
- Epidemiology: Currently considered of secondary importance by the group.

- **Further steps:**
- **Intensify toxicological research**
- **Give more consideration to the exchange between toxicologists from science, public authorities, researching industry and NGOs, especially in existing working committees**
- **Follow-up: Discussion of individual cases in occupational medicine: Setting up of a small dialog group to discuss and to look into observations from the medical practice of occupational and environmental physicians and toxicologists from NGOs, science and industry.**
  Open: Who takes the lead in organizing?

Measuring technology

- The available study by BGIA (Institute for research and testing of the German Berufsgenossenschaften) on ultra-fine aerosols at the workplace is to be examined, regarding transferability of procedures / orchestration with toxicology.
- The problem of assigning sources of exposure was discussed intensively.
- The development of personal measuring methods should be driven forward fast.

- **Further steps: Orchestration work in existing, well-structured committees**

Classification

- Discussion of "easy accessible surface" as classification criterion
- Toxicological potential and measuring technology must be clarified as a priority
- Inclusion of coated nanomaterials – differentiation is necessary

- **Further steps: Evaluation of existing data sets on "existing" nanomaterials**

Safety data sheets (SDSs) / Protection measures

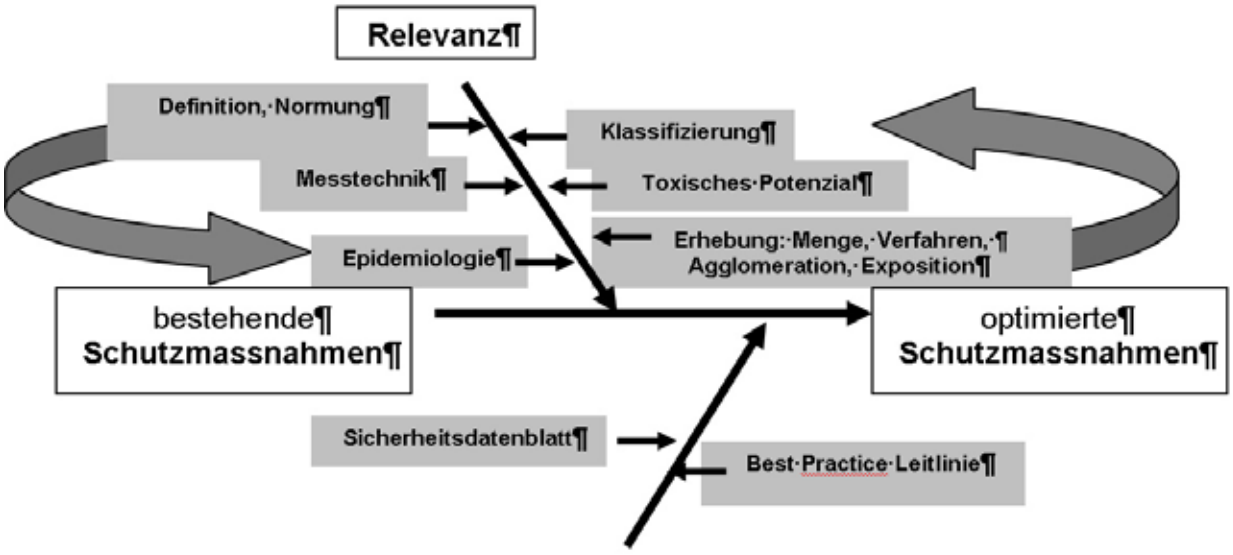
- It is required by law to complete SDSs for dangerous substances. SDSs must be completed if nanomaterials are dangerous.
- Industry is already making a classification of substances (product responsibility).
- Guidelines for good handling for nanomaterials are being developed.

- **Further steps: Intensify the exchange betweens stakeholders**

Merging:

Irrespective of the time sequence, the subjects have a circular character that cannot be broken. For example, without fundamentals in toxicology and measuring technology, it hardly makes sense to carry out a comprehensive survey or to prescribe protection measures. Data on workplace exposure are also the prerequisite for a toxicological assessment of nanomaterials. Consequently, the various work steps will require from all stakeholders a wide perspective for the overall process, the readiness to compromise in interim solutions, and much patience.

Factors for determining the relevance to regulatory processes, protection and information measures for industrial health and safety



The next events in the VCI dialog series will be about environmental and consumer protection / product safety.

Stiftung Risiko-Dialog, St Gallen, 5 October 2005

II. Dialog Documentation

1. New Materials – New Questions?

Welcome by Dr Gerd Romanowski, VCI

Nanomaterials offer fascinating fields of innovation for various sectors. Automobile coatings, sun screens, textiles, wood protection products and surface finishing are just a few examples for the future potential of nanomaterials. Equally promising are nano-innovations in medicine, pharmacology and information technologies. In many cases the German chemical industry provides the basis for future developments, with great chances for opening up new markets. Besides the USA and Japan, Germany is one of the leading competitors worldwide, both scientifically and economically. If innovations are to be sustainable, they must be safe for humans and the environment. Therefore, VCI is very intensively dealing with safety research issues.

Active safety research and stakeholder dialogs

Over the last few months, several relevant research projects started in Germany. Chemical industry companies are actively participating in projects such as "Nanoderm" and "Nanosafe" at EU level, and in "Nanocare" which is promoted by the German federal ministry of education and research (BMBF). In recent years, several new projects and bodies were initiated also internationally, for example at OECD level or in the 7th research framework program of the EU. Also the global International Council of Chemical Associations (ICCA) cooperates actively with VCI in the exchange of experiences and in the definition of operating guidance. Industry has a central interest in the safe use of its products. According to the current state of knowledge, companies take a highly responsible attitude in the handling of nanomaterials, benefiting from several decades of experience.

Dialog event series starts with industrial health and safety

VCI has initiated a dialog event series with industry, science, public authorities/ ministries, NGOs, employers' liability insurance associations and trade unions. The aim is to discuss chances and risks with stakeholders and to jointly identify need for action. The first stakeholder dialog focuses on industrial health and safety, intended to compile knowledge on toxicology, epidemiology and measuring technology. At the same time, this is about information, communication and networking between stakeholders. Further events in the series will cover the fields of environmental protection and health protection of consumers / product safety.

Cooperation with the foundation Stiftung Risiko-Dialog

Stiftung Risiko-Dialog, St Galen/Switzerland, is responsible for the concept and the implementation of the VCI dialog event series. Stiftung Risiko-Dialog stands for an independent and professional moderation, with many years of experience in many risk issues. Regarding nanotechnology, several dialog and research projects were already realized.

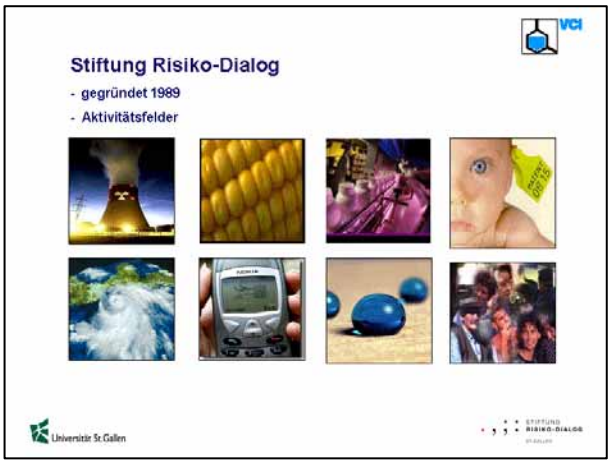
Publication

The dialogs are minuted, and the results are presented in a summary version and in a long version. All results will be made available in electronic form to the participants. Expressly requested is a discussion of results in the organizations of participants, in order to carry on the largest number possible of impulses.

2. Stakeholders in dialog

Typical communication patterns and questions

Summary version of the lecture by Prof Dr Matthias Haller, President of Stiftung Risiko-Dialog



After a presentation of the team, Matthias Haller gives initially an introduction to the history and the working method of Stiftung Risiko-Dialog. Since 1998 the foundation has been a dialog platform for stakeholders from industry, science, NGOs, media, politics and public authorities. The foundation has the non-commercial mandate of improving risk communication in society. Therefore, it must maintain neutrality. Several stakeholder and citizens' dialogs as well as conflict management measures were, and are being, conducted in the following areas: Energy dialog, red and green genetic engineering, stem cell research and patenting, climate research, electromagnetic fields (EMF), nanotechnology and social policy in Switzerland.

Foundation Stiftung Risiko-Dialog – established in 1989 – fields of activity

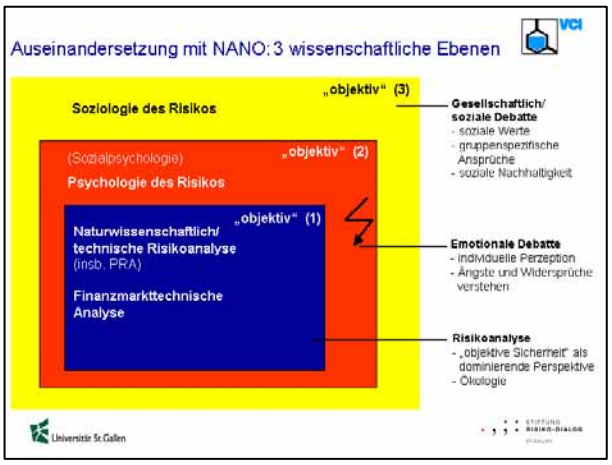
Risk dialog in the field of tension between opportunity and danger

Activities are based on an understanding of "risk" as a field of tension between opportunity and danger. The goal of dialogs is to build knowledge about risk processes and to reflect on perspectives of risk perception and evaluation. Jointly, participants are

to work on options for action that are acceptable in the meaning of sustainability. Consequently this is about a targeted use of opportunities, giving consideration to potential dangers.

The three levels of risk communication

Haller draws attention to the 3-level model which shows the various levels of communication and perception of risk issues; this model is the basis for the work of the foundation. In the public debate, natural science-technical arguments (blue) are faced with fears and hopes at the emotional-psychological level (red). A third (yellow) societal-sociological level refers to questions on the handling of the issue in society. The conflict increases in intensity if it is about values or social sustainability at societal level (yellow), because this is where risks are judged. Moreover, argumentation patterns from psychological or sociological levels are noticed with much more intensity by the general public and the media.



Typically, arguments from research and industry are at the "blue" level. It is tried to respond to hopes and fears (red level) or to arguments quoting values (yellow level) with more scientific-technical information (blue level). However, the judgment of risks rather depends on personal experiences and expectations of the actors and institutions involved. They are decisive for the trust in the responsible handling of risks. Finally, this trust can be created only through an open dialog, which should be as critical as possible, at all three levels. This dialog must face the hopes, fears and judgment criteria of all stakeholders.

Coupling of risk types in the nano-debate

According to Haller and Grobe, generally three different risk types can be differentiated: Accident risks, system risks and future risks. Accident risks refer to concrete accidents, such as e.g. damage by elements, industrial accidents, blackouts or accidents caused deliberately through terrorist acts. The risk is covered by statistics and forecasts; suitable protection measures in risk management are of a technical nature, too. One part of the expected risks in industrial health and safety refers to industrial accidents, unintended releases or exposure of workers.

The second class comprises system risks. These risks are not due to accidents but arise in normal operations of the system. One example is genetic engineering, where e.g. normal outcrossing, that had to be expected, became the subject of discussions. This risk class is dominated by general risk and technology assessment and the determination of limit values, which define e.g. shares in mixtures or distances between fields. It now emerges that system risks will have to be considered in the nano-debate, too. This shifts risk management from the level of operating plants to the level of regulatory regulation and assessment by public authorities and technology-evaluating institutions.

The third class includes future risks that can hardly be estimated or handled, because the amount of data available is still too low. The debate is about values, the issue of using opportunities and innovative potentials. The conflict of values as such becomes the risk. Risk management must intensively deal with the expected measuring and assessment yardsticks. The conflict of values defines e.g. whether – in the meaning of the precautionary principle – possible risks in the situation of the (not yet) "knowing" are so high that an opportunity should not be used. Currently this debate can be observed also for nanotechnology.

This has the following consequences for nanotechnology:

1. Nanotechnology is discussed simultaneously at all 3 levels (blue, red, yellow)
2. The 3 risk types (accident risk to conflict of values) are perceived simultaneously, but no differentiation between them is made
3. We are in the early stage of the debate, without well-founded data

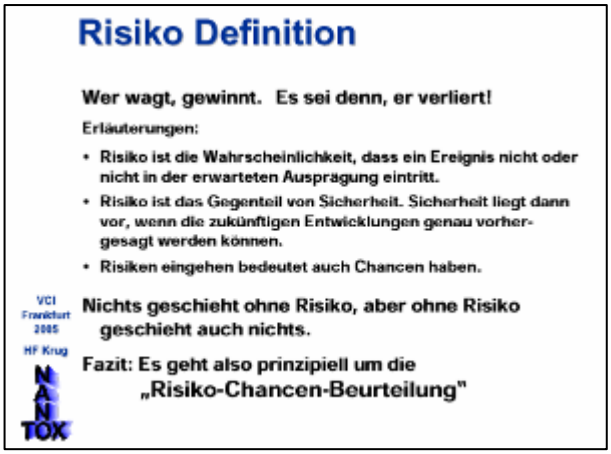
This means:

1. All stakeholders must expect a rising complexity of the debate.
2. With the rising complexity, the trust in institutions moves to the fore.
3. It will be unavoidable to strive for a better differentiation than expected so far, in order to more adequately address in the future all 3 levels and 3 risk types in the debate.
4. A networking of actors is essential, in order to cope with the rising complexity and to generate the necessary knowledge, as a basis for decision-making.

The concept of the stakeholder dialog on industrial health and safety incorporates these four consequences.

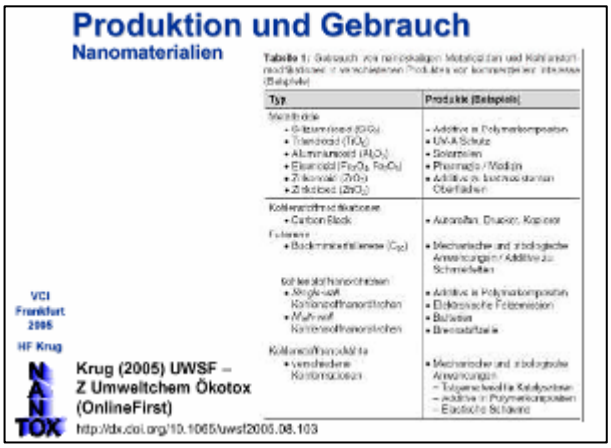
3. Thought-provoking lecture from toxicology – Are nanomaterials dangerous?

Summary version of the lecture by Prof Dr Harald Krug, Forschungszentrum Karlsruhe



Rising dangers and undesirable side-effects of nanosciences and nanotechnologies are increasingly discussed in various print media, making such aspects perceivable for a general public. Besides the discussed hazards to health and the environment, Prof Krug also sees unrealistically high expectations - stirred by industry and science – as a problematic risk potential for nanotechnology. If developments of promised uses or therapeutic successes do not come true or if unexpected risk issues arise, societal institutions connected with this technology will lose in credibility. However, as a matter of principle all new technology developments are inseparably linked with risks.

If the motorcar – with 500,000 dead and 23 million injured annually in road traffic – was assessed according to today's safety requirements, this technology would most probably not be approved. Accepting risks does not only mean analyzing dangers, it also means accepting opportunities and being able to use them. Consequently, the assessment of new technologies is always about weighing potential dangers and potential chances against each other. Nothing happens without risk, but without risk nothing happens either, so Prof Krug.

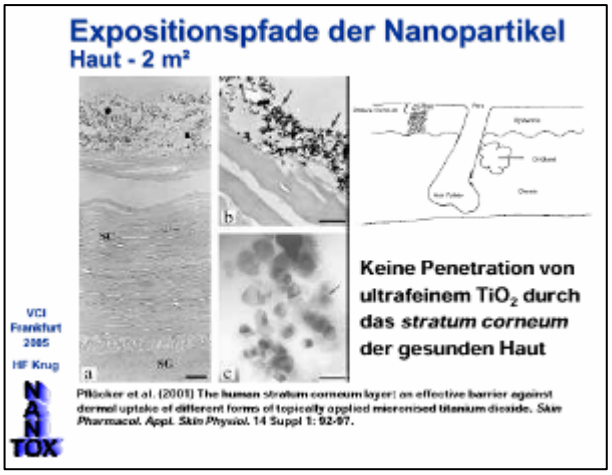


Nanosciences and nanotechnologies have already produced a range of products in very different applications. Nanomaterials can be released directly into the atmosphere, in manufacture and in decanting. Already now people come in contact with these materials at their workplace. It is uncontested that e.g. fine dusts or ultrafine dusts involve risks, such as e.g. adverse health effects. Richard Smalley of Rice University estimates that,

in the next five to ten years, hundreds of tons of new nanomaterials will be produced worldwide. Exposure of humans will rise, without the toxicity of such new nanomaterials being fully clarified.

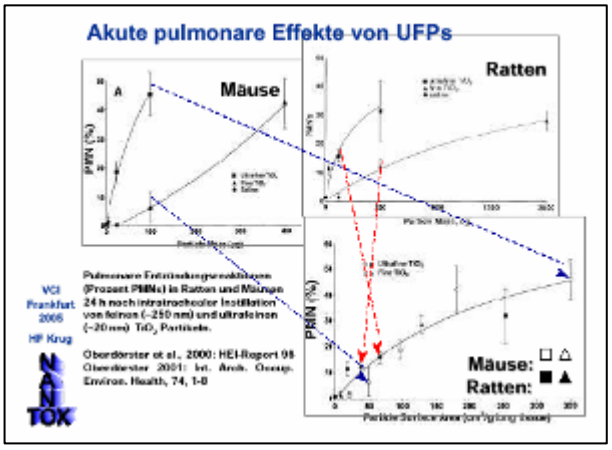
In toxicology, risks of substances are estimated in a four-tier approach:

1. Hazard identification
2. Dose-response assessment
3. Exposure assessment
4. Risk characterization



A number of occupational medicine and toxicological studies on health implications of particles and materials in the nanoscale range are already available. Some of them are presented here. Selected were studies on titanium oxide, silicone dioxide, nickel and carbon nanotubes, in order to outline some substances frequently used in industry and research, as they were mentioned in interviews preparing the workshop. Well-researched is e.g. titanium dioxide (TiO_2). For example, (Pflücker et al. 2001)[1] note that TiO_2 does not penetrate the body through healthy skin. The question is open how injured, inflamed or particularly sensitive skin reacts. It is assumed that then the entry barrier for particles is lower.

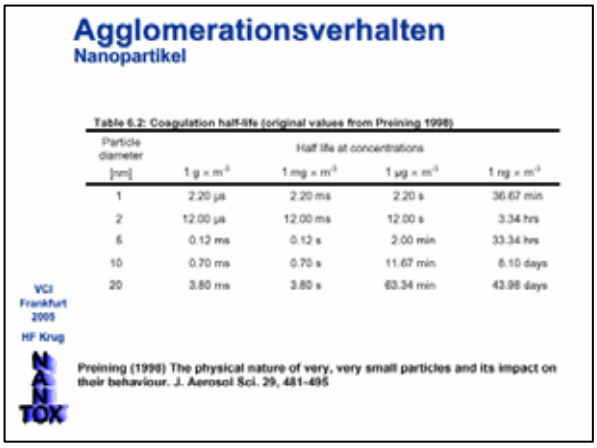
1 Pflücker et al. (2001) The human stratum corneum layer: an effective barrier against dermal uptake of different forms of topically applied micronised titanium dioxide. Skin Pharmacol. Appl. Skin Physiol. 14 Suppl 1:92-97.



(Obersdörster 2001)[2] examined the impacts of various doses of fine and ultrafine TiO_2 on lung tissue of rodents, proving dependence between particle surface and intensity of the inflammation reaction. A study by the research group around Peter Gehr at the anatomical institute of Bern University shows that TiO_2 is respirable and deposits in vascular dothelia in the body, also outside lungs (Kapp et al. 2004)[3].

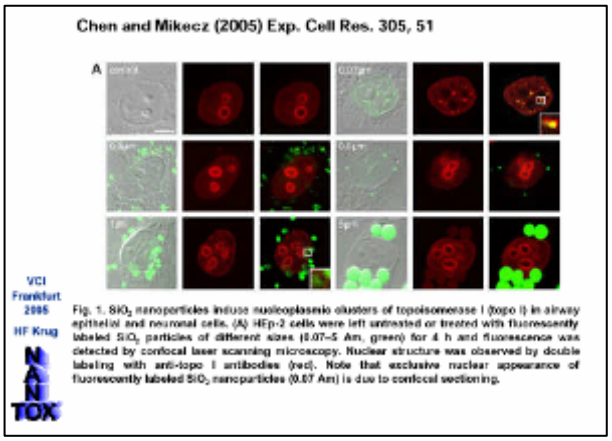
2 Oberdörster, Günther (2001). Pulmonary effects of inhaled ultrafine particles. Int. Arch. Occup. Environ. Health, 74, 1-8.

3 Kapp et al. (2004). Microsc. Res. Tech. 63, 298-305



The agglomeration behavior of man-made particles of different materials was also examined by (Preining 1998)[4]. Half-times of primary particles decrease, the smaller the particles or the larger their surfaces, respectively. Toxicological studies frequently use man-made, clearly defined nanoparticles. This is a central prerequisite for the reproducibility of tests and the comparability of results.

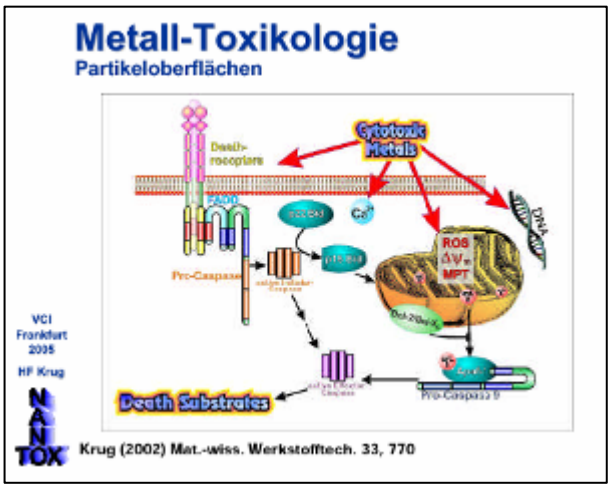
4 Preining (1998). The physical nature of very, very small particles and its impact on their behaviour. J. Aerosol Sci., 29, 481-495.



However, toxicological studies often bring contradictory, not clearly interpretable results. For example, a research group around Anna Mikecz proved, according to a press release of Düsseldorf University of 21 February 2005, that a certain silicic acid (SiO_2) can influence functions of the cell nucleus. It remains unclear why particles of that size make their way to the cell

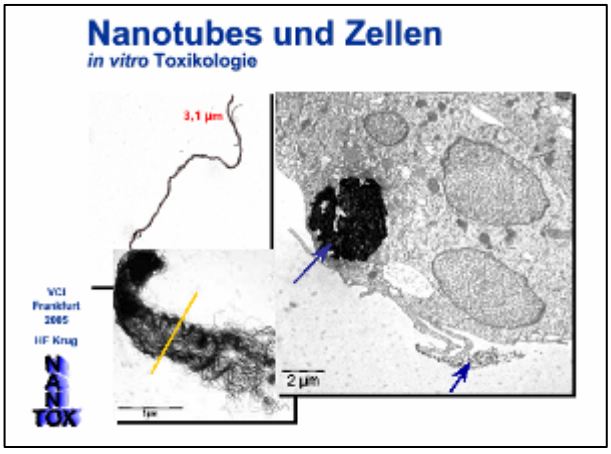
nucleus, as a research group around Panté and Kann noted in 2002 that particles of that size do not fit through nuclear pores. With his own group, Krug also studied silicate particles. He proved that SiO_2 of < 60 nm particle diameter significantly increase the lethality of endothelial cells (Wottrich et al. 2004)[5]. These findings, too, must be viewed with care, because the group around Krug works with in-vitro studies. Here, often very high doses are necessary to be able to prove an effect.

5 Wottrich et al. (2004). Int. J. Hyg. Environ. Health, 207, 353.



Toxicological impacts of metals are a further problem. Several relevant studies have been performed. Oller (2002)[6] studied various nickel particles. He noted that, with decreasing size, the particles can increasingly go through cell membranes. Once they are in cells, they either start interacting with macromolecules, such as e.g. DNA, or they are dissolved. This leads to free metal ions, which are toxicologically relevant, because they trigger oxidative stress or they bond directly to DNA where they cause strand breakage.

6 Oller (2002). Environmental Health Perspectives, 110, 841.

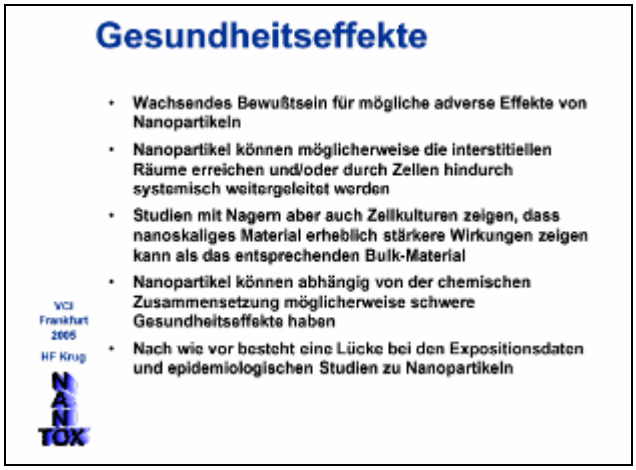


Regarding carbon nanotubes, it was found that their instilling in lungs of test animals causes blackening and cell accumulation (Wahrheit et al., 2004)[7]. With 5 mg/kg of deposited material, Wahrheit et al. (2004) proved a mortality rate of 15% of test animals. As carbon nanotubes were directly instilled in lungs of rates, the animals suffocated from the bolus and did not die from the toxic impacts of deposits of carbon nanotubes.

7 Wahrheit et al. (2004). Toxicol. Sci, 77, 117-125.

Krug and his group showed in cell culture studies that undersupplied cells die off through contact with carbon nanotubes, due to apoptosis (programmed cell death) (Wörle-Knirsch et al, forthcoming).
The awareness is growing of possible disadvantageous effects of nanoparticles. Based on available toxicological studies, there is the suspicion of some nanoparticles being systemically passed on through cells, with the possibility of deposits in cell gaps, organs and tissues. Studies in rodents and cell cultures show that materials in the nanoscale range can display considerably stronger effects than corresponding materials in larger size ranges.

Depending on their chemical composition and their morphology, nanoparticles can possibly lead to serious health effects. Now as in the past, relevant data are lacking for assessing amounts of exposure for nanoparticles. Also lacking are exposure studies at the workplace and epidemiological studies in the population. The aim must be to reduce, to an acceptable level, toxicologically relevant effects of nanomaterials and thus the risks of nanosciences and nanotechnologies.



4. Nanomaterials at the workplace: Questions, priorities and suggestions from stakeholders

First impressions from expert interviews
Summary version of the lecture by Dr Antje Grobe, Stiftung Risiko-Dialog

Nanotechnology is not (yet) a risk issue

The concept for and the success of dialogs depend on the respective social context and on the expectations to such events. Regarding dialogs about nanotechnology, the perception in the public at large is generally rather positive. Surveys from the

years 2002-2004 show that, in a comparison of countries, only ca. 20% expect nano-technology to bring more risks than chances. In Germany, 60% of respondents clearly expect more chances than risks, the others are undecided. For VCI, the VCI media archive - with around 250 articles and 48 press organs - was evaluated in spring by the foundation Stiftung Risiko-Dialog. In the following months, a reference study was performed – with further 220 articles from 4 selected organs (Die Zeit/weekly newspaper, FAZ, Financial Times Deutschland and NZZ/daily newspapers), in order to review the selection of articles and to be able to study developments over the course of time. Results were stable, also in the reference study. Some 90% of media reports were clearly positive, reporting focused predominantly on chances, or reporting was balanced to neutral. Reporting on nanotechnology was in connection with innovative applications or outstanding researchers. So far, nanotechnology is not covered mainly as a risk issue.

Risk reporting will increase

Not yet is the correct wording, so Antje Grobe, because in parallel to the media analysis, depth interviews were conducted at St Gallen University and Stuttgart University. Stakeholder interviews in the media clearly point to an expectable increase in risk issues in 2005/2006, for the following reasons:

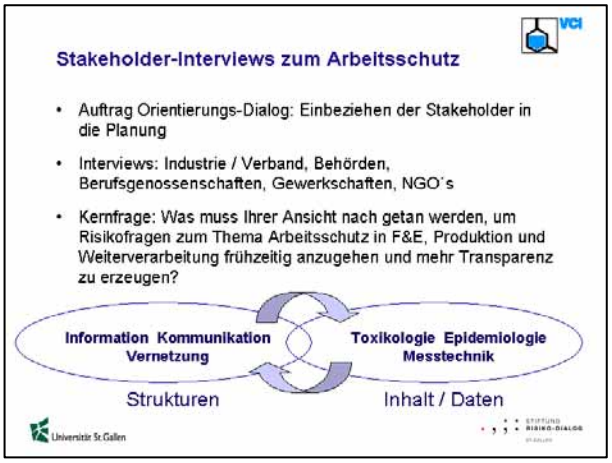
1. Media reporting is about real occurrences and events. For the coming months, the first results of the risk and technology assessment are expected. Thus risk issues will be in the focus of reporting. Also expected are reports on representative citizens' participation processes and new attitude surveys. For example, the first nano-juries were held in England, where citizens formulated critical concerns. Such citizens' conferences or PubliForen are planned for 2006 also in Germany and in Switzerland. A new study in the USA (Informed Public Perceptions of Nanotechnology and Trust in Government, J Macoubrie, 2005) shows e.g. a massive gap in trust vis-à-vis companies and public authorities. The media will take up these subjects and events.

2. A shift in issues, towards known risk issues from past debates, can be expected. It clearly emerges from stakeholder interviews that campaigns of NGOs (e.g. ETC Group) focus predominantly on known topics, which are easy to further build on. Foodstuffs, agricultural products and military applications are fields of use for nanomaterials that trigger familiar patterns of rejection and distrust. The much quoted similarity with genetic engineering will become much more visible in the future.

Criticism is expressly requested

However, the depth interviews also show that, in the wake of the genetic engineering debate, much openness and strong criticism are desired. Concerns and fears of the general public are to be given consideration right from the start. In earlier debates about energy, genetic engineering or stem cell research, only two polar positions were discernible – between speeding up innovations for the location of industry and research, and slowing down processes in the meaning of sustainability and Responsible Care. Polar positions could be assigned to certain actors. In the stakeholder interviews on nanotechnology, both polar positions are found again in the argumentation patterns, but they are mixed when assigning them: Industry delegates use sustainability as an argument, while environmental organizations and media or public authorities want more innovation at the industry location. It is "good manners" to show openness and a readiness for dialog. This is done by all stakeholders alike.

Stakeholder interviews to prepare VCI dialog



In order to prepare the VCI dialog on industrial health and safety, Stiftung Risiko-Dialog held interviews with all stakeholders involved. The aim was to attune the workshops, in a result-oriented manner, to the various needs.
Two focal subjects emerged from interviews with industry/association, public authorities, employers' liability insurance associations (Berufsgenossenschaften) and NGOs:

1. Information, communication and networking: Background for this circle of subjects are the different information levels of stakeholders. Outside industry and public authorities there is little knowledge of who produces what, which processes are used, how much exposure there is, etc. The idea of the workshop was to discuss, at a structural level, how to improve the exchange of information between stakeholders. Therefore, a fine balancing of concerns is necessary, because the goal is to exchange information without simultaneously revealing business secrets.

2. The second focus is formed by questions regarding contents and the insufficient data situation for the toxic potential of nanomaterials, epidemiology and measuring technology. Here, too, the background is the wish to build knowledge jointly with stakeholders and to identify knowledge gaps. It should be examined how arising questions can be adequately covered within existing institutional structures, or if there is a need for further-going dialogs. In the following, Dr Grobe gives an introduction to the exact questions from stakeholders that created the working basis for the workshops.

5. Issue workshop: Content supplements and orchestration – dialog groups

Moderation Dr Antje Grobe

In the next module, the issue lists of the workshops were discussed by the table groups of the plenary.
The goal of the morning plenary was to critically put into question the issues and mandates from the interviews, and to make precisions and supplements. All comments were simultaneously incorporated in the templates and then duplicated.

The workshops in the afternoon started with the issue lists, as revised by all participants.

6. Dialog groups on industrial health and safety

Workshop 1 – Information, communication and networking

Issue 1: Definition

Interview questions and supplements
How can nanoparticles be defined in a useful way?
- Referred to size, to substances or technologies in context with applications

Knowledge and knowledge gaps

Parameters of definition

- A definition oriented purely to size (< 100 nm) is not enough.
- Measuring methods must integrate particles and materials up to 500 nm.
- Besides size, an assessment must include bioavailability: the 3 parameters: morphology, chemical composition and agglomeration behavior contribute to the degree of danger.
- The definition should be specified regarding risks. However, definitions are also decisive for research promotion and risk communication.
- A differentiation is necessary between intended "nanoparticles" and "ultrafine particles" that unintentionally reach the environment.

Goal: Safe handling and use of nanoparticles

- The group discusses necessary limit values, e.g. for the inhalation of intentionally and unintentionally produced particles.
- For the handling of nanoscale solids, technical measures are available and need to be implemented consistently. Existing measures offer good protection. Where there are open questions they need to be solved, in order to improve existing measures.

- **Further steps**
- **Agreement:** Today's deliberations are about intended nanoparticles.
- **Intensify standardization activities:** A number of standardization activities are starting worldwide, in order to elaborate an ISO standard. Germany must make strong contributions to these standardization activities, to help shape potential regulation. There is the danger of the nomenclature being reproached as "one-sided" if there is no participation of environmental organizations and public authorities. For this reason, an early involvement of stakeholders is essential – achieving broad consensus. Involving all stakeholders would be ideal, but this is difficult in practice.
- Standardization is the prerequisite for regulation. Hasty action is not advisable; in particular, US standards should not be taken over "blindly".

Issue 2: On-site survey: Manufacture/Use

Interview questions and supplements

- What is manufactured? Which volumes?
    - How can aggregated data be gathered without revealing business secrets?
    - Which materials in the nano-range have been on the market already for many years?
- What data are to be gathered for which purpose? Who merges data?
- Is there exposure? What problems could occur with exposure?
- What processes are used? Monitoring? (Measurability of exposure, standardization and validation)
- Are systems closed? (interface plant-human, filter, disposal)
- What epidemiological findings are available?
- Protection measures?
    - Are commonly used filters efficient, and are existing protection measures enough?
    - How can existing protection rules be integrated?

Knowledge and knowledge gaps

- There is much need for an overview of what is manufactured – how, where and in which volumes. The existing situation should be established, transparency for existing data sets should be ensured, and further necessary data of fundamental importance should be gathered without delay.
- Data – in particular on volumes – must be gathered, in order to find out about relevance to regulation. Then, those data must be summarized into work information.
- Substance-specific data gathering is necessary: Agglomeration and modeling of the decomposition of agglomerates must be centrally considered.
- Industry successfully implements preventive occupational health and safety in the handling of materials with very small particles. Already now, established industrial health and safety measures provide a high level of safety at the workplace.
- Knowledge should be generated on whether new standard protection measures are necessary.
- There is the need to gather information by way of questionnaires, also on such aspects.
- In order to obtain the required information, a cooperation should be set up. The question of regulation should be a secondary priority. Delegates from industry and public authorities concur with this, and they agree the following steps:

- **Further steps:**
- **Questionnaire survey among VCI member companies on exposure and occupational health and safety measures:**
- **Questions are worded jointly by BAuA and VCI**
- **Anonymization for member companies by VCI**
- **Evaluation BAuA**
- **Open: Inclusion of start-up companies and science**
- **Open: Consideration of anti-trust aspects**

Goal: Improving the exchange of information between stakeholders and improving the data situation

Issue 3: Code of good practice

Interview questions and supplements

- Circulation of guidance and safety data sheets / training
  Training of multipliers, taking into consideration small operations
- Checklist: Personal protective equipment / Safety at the workplace
- How can uncertainty / "not knowing" be prevented?
- How can the guiding ideal of Responsible Care be implemented under innovation pressure?

Knowledge and knowledge gaps

- Three approaches need to be combined with each other: Data/information gathering, prevention and communication. Here, it must be ensured that knowledge gaps are dealt with responsibly, too.
- Questions of industrial hygiene are discussed in a VCI working group. Guidance is to be developed, in cooperation with public authorities.
- The criterion for "good practice" is how uncertainty is dealt with.
- High transparency is demanded for basic data and evaluations and for communication with other interest groups – toward a fast, joint risk assessment.
- Stakeholders on the scientific side should be addressed as peer groups, for their participation. Projects such as "nanosafe2", "nanocare", "nanoderm" need to be included. Science should be more strongly involved, within the workshops of the foundation Stiftung Risiko-Dialog.

- **Further steps:**
- **Continuation of the work in expert committees**
- **Systematic involvement of the various stakeholders in the dialog**
- **Intensification of the dialog with outside parties**

Workshop 2: Toxicology, epidemiology and measuring technology

Issue 1: Toxicological potential

Interview questions and supplements

- What types of experiments, evidence or "life cycle analysis" are needed? Which experimental standards need to be defined?
- Endpoints: Which impacts and effects should be examined? (blood-brain barrier, cardiovascular, inflammations of alveoli, autoimmune diseases ...) barrier function of skin and gastrointestinal tract
- Are there effect thresholds for concentrations or incorporations? Clarify limit values, weigh other effects
- Accumulation effects
- Search for analogies is deemed problematic

Biopersistence? Bioavailability?

- Available knowledge? Few publications

Knowledge and knowledge gaps
Toxic potential

- The group discusses unpredicted properties in dependence of particle size, on the example of gold particles.

- Another quoted example is silicon dioxide, whose negative impacts on the cell nucleus were researched. For NGOs this information is of very high importance, because galenic additives in medicinal and food products are common. Industry explains that a more precise differentiation is necessary, as four different types of silicic acid are known, with very different stabilities. Silicic acids should not generally come under suspicion; it must be examined precisely how these particles are handled. At present, mainly liquid silicic acids are used. A publication in November 2005 (ECETOC) will also cover the subject of silicic acid.
- Definition of endpoints: Which impacts should be examined? The group discusses effects regarding the blood-brain barrier, cardiovascular, inflammations of alveoli and autoimmune diseases.
- Intake routes: The group agrees that the respirability of particles is of great importance in occupational health and safety. Knowledge regarding disposition is available. NGOs plead for a more comprehensive approach that considers skin, eyes, nose and the gastrointestinal tract as uptake organs, as well as the subject of intake via placenta. Then the group discusses the currently available knowledge on these subjects:
    - Skin: The EU project Nanoderm has been running for 1.5 years to 2007, parts are already published.
    - The NGOs report about the statement by an established dermatologist who is observing an increase in allergies to TiO_2, since TiO_2 is used in sunscreens. Sensitization studies of the cosmetics industry do not confirm this. Industry points to the Information Network of Departments of Dermatology (IVDK) which has a broad data basis on allergies that, however, does not list TiO_2 as allergen.
    - The NGOs point to a study of fullerens which shows that nanoparticles can reach the brain, via the eye (Uveitis) or the olfactory organs (example: study Oberdörster).
    - Gastrointestinal: Specific data are available, e.g. with reference to the intake of medicines. Most group members do not think that this subject is of high priority in industrial health and safety.
- The recommendation from NGOs for individual examinations (analysis of the toxic potential of each substance in the various size ranges) is discussed.
- A harmonization of methods and measures and a closer cooperation between the stakeholders are striven for, in order to ensure the practicability and the relevance of experiments.

- **Further steps:**
- **Intensification of toxicological research**
- **More consideration – especially in existing working committees – of the exchange between toxicologists from science, public authorities, researching industry and NGOs.**

Issue 2: Epidemiology

Interview questions and supplements of subordinate importance in terms of time

- Which data can be gathered in what way? Do we need a biomonitoring? Are existing statistics sufficient?
- Occupational medicine should have an accompanying role – not only after findings become available. Pathology is important, too, and should be included in data/information gathering.

Knowledge and knowledge gaps

- Clarify the fundamental question: Who is impacted, and how can large figures come together? (working results of workshop 1)
- Data are not available as yet. There is much need for research. The possibility should be examined to draw new findings from existing data.
- For a determination of exposure, a separation of effects and a clear allocation of exposure must be possible.
- It was proposed to intensively discuss the subject of nanomaterials in existing working committees of company physicians of the chemical industry, and to invite interested environmental physicians.

- **Further steps:**
- **The group defines this subject as being of subordinate importance in terms of time.**
- Follow systematics of logical sequence: First toxicology, then epidemiology
- The time horizon is open, at first more information density must be achieved
- Information sources:
    - Published information on the internet
    - GSF Institute for Epidemiology

Special issue: Pathological examinations

- The NGOs report a case of a worker who came into contact with nanomaterials and died from an unidentified cause. As the patient's previous history did not point to any other cause of death, the NGOs' conclusion was a connection with nanomaterials. No pathological examinations were performed that could have substantiated or refuted this suspicion. The delegate from science notes that, in the event of a connection with nanomaterials, clinical symptoms would have occurred earlier. It was not possible to cover more profoundly several requests for further information from industry and science.
- The group fiercely discussed how to deal with non-clarified, isolated cases. Here, too, it was recommended to take up such cases individually and to process relevant indications systematically and scientifically.

- **Further steps:**
- **Follow-up: Discussion of isolated cases in occupational medicine: Setting up of a small dialog group to discuss and to look into observations from medical practice of occupational and environmental physicians, also involving toxicologists from NGOs, science and industry.**
  Open: Who takes the lead in organizing?

Issue 3: Measuring technology

Interview questions and supplements

- State of the art? Any need for the future?
- Standardization is the great challenge for measuring technology.
- What is to be measured? Number concentration instead of weight
- Immission/emission register – comparison environmental burden – burden at the workplace
- For what applications do measuring methods need to be developed?

Knowledge and knowledge gaps

- Basically, the current state of the art allows a selective measuring of nano-materials at the workplace. The available study by BGIA on ultra-fine aerosols at the workplace is to be examined regarding transferability of methods. 1st version of the study published: "Ultrafeine Aerosole an Arbeitsplätzen – Konventionen und Beispiele aus der Praxis" G. Riediger und C. Möhlmann. Sonderdruck aus: Gefahrstoffe/Reinhaltung der Luft 61 (2001) Nr. 10, S. 429-434
- Further sources of information:
  - Gruppe Fissan / Kuhlbach, IUTA in Duisburg/Essen
  - Database MEGA of BIA on burdens at the workplace could be expanded
- International study on carbon black by ICBA (International Carbon Black Association). No increased concentration at the workplace was found.
- Intensively discussed was the problem of assigning exposure sources.
- The development of personal measuring methods should be driven forward fast.

- **Further steps:**
- **Coordination work in existing, well-structured committees**
- **BAuA offers examinations in industrial companies regarding workplaces.**

Issue 4 Classification

Interview questions and supplements

How should nanomaterials be classified?

a) by their characteristics: form, geometry, agglomeration, bioavailability, differentiation/composition as substances

b) Hazard classification: harmful, carcinogenic, dangerous for the environment ...

- How can the process between actors and institutions be coordinated fast?

Knowledge and knowledge gaps

- Discussion on "easy accessible surface" as classification criterion.
- Toxic potential and measuring technology must be clarified, being top priorities.
    - Available data on 'old' substances should be put in relation to 'new' data, in order to find out what is already covered. Who could link 'new' with 'old'? Who is competent? Joint validation of methods is necessary.
- Inclusion of coated nanomaterials – differentiation is necessary.

- **Further steps:**
- **Evaluation of existing data sets on 'old' nanomaterials**
- The group pleads for a merging of knowledge on which substances should be examined. From the NGOs' viewpoint, also the large number of research institutes with very small quantities of nanomaterials should be taken into consideration.

Issue 5: Code of good practice / Safety data sheets / Protection measures

Interview questions and supplements

- Which protection measures are necessary in what context? Concrete guidance would be excellent (manufacture, packaging, disposal)
- Guidance for safe handling / work organization: What alternatives are there?

Knowledge and knowledge gaps
Safety data sheets / Protection measures

- The law requires the completion of safety data sheets (SDSs) for dangerous substances. Where nanomaterials are dangerous, SDSs must be completed.
- The group discusses the problem of identifying danger, as a prerequisite for SDSs.
- Industry already makes a classification of substances (product responsibility).
- Guidance for safe handling of nanomaterials is being elaborated.

- **Further steps:**
- **Intensify the exchange between the stakeholders**

7. Excerpt from final statements

All participants receive minutes of the event with a summary version, detailed dialog documentation, and a list of participants as attachment. An open use of the minutes and a continuation of discussions inside the participants' organizations are expressly welcomed.

Conference October 11/12 2005 in Bonn
BMU (German federal ministry for the environment) / UBA (German environmental agency) / BAuA (Federal institute for occupational safety and health)

The results of this workshop will be included in the conference on October 11/12 in Bonn, within the workshop on occupational health and safety where Dr Grobe will present the outcomes.

Dr Müller-Helmbrecht (BMU) cordially invites all participants to attend the conference. The two-day conference is seen as a continuation of the VCI dialog and the dialog within OECD. Everyone is called upon to contribute their work results to this conference of the federal government and OECD. This is to strive for an early global harmonization, with a view to cooperation and coordination – in order to avoid national go-it-alone action/regulation.

The VCI dialog on industrial health and safety was thought to be excellently prepared, with very precise questions in the workshops. Praise was given to the open dialog and the moderation.

On behalf of VCI, Dr Gerd Romanowski thanks all participants, the moderators Prof Dr Matthias Haller and Dr Antje Grobe and the team of the foundation Stiftung Risiko-Dialog. He invites the participants to also attend the next events in the VCI dialog series, on the issues of environmental protection and consumer protection/ product safety.

Dialog documentation: Stiftung Risiko-Dialog, St Gallen, October 5 2005