Latest research results on the effects of nanomaterials on humans and the environment: DaNa - Knowledge Base Nanomaterials

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Abstract. Nanotechnology is considered one of the key technologies of the 21st century. The success of this fascinating technology is based on its versatility. It will bring about fundamental changes of basic research as well as of many sectors of industry and also of daily life from electronics to the health care system. However, consumers often miss reliable and understandable information on nanomaterials and all aspects of this versatile technology. A huge body of data on the potential hazards of nanoobjects towards human and environmental health already exists, but is either not easily accessible for a broad audience or presented unprocessable for non-experts. But risk communication is an essential and thus integral component of risk management. For that purpose, the DaNa-Project aims at filling this gap by collecting and evaluating scientific results in an interdisciplinary approach with scientists from different research areas, such as human and environmental toxicology, biology, physics, chemistry, and sociology. Research findings from the field of human and environmental nanotoxicology are being prepared and presented together with material properties and possible applications for interested laymen and stakeholders. For the evaluation of literature a "Literature Criteria Checklist" has been developed as well as a Standard Operation Procedure template (SOP) based on careful scientific practice.
1 Introduction

Nanomaterials (in this article meaning “any material containing nanoobjects”) comprise a large variety of substances which come in many modifications. A huge amount of data has been published in recent years on the toxicology of nanomaterials, yet it is difficult to get a general overview on the effects of a specific material. Furthermore, the information contained in the scientific literature is hardly assessable for consumers interested in health aspects of nanomaterials. Hence, a knowledge base was created providing a unique combination of material science-based information on nanomaterials and nano-applications combined with toxicological data. This was achieved by collecting scientific results from publications, research projects and latest news on human and environmental toxicity in the field of nanotoxicology. This state of knowledge has been wrapped up in a knowledge base and presented in a transparent understandable format.

In an interdisciplinary approach, the DaNa-project team assembles scientists from different research areas, such as human and environmental toxicology, biology, physics chemistry and sociology, who create this transparency and present the research on nanomaterials and their effects on humans and the environment in a public orientated way.

Therefore the www.nanoobjects.info knowledge base provides easily comprehensible information regarding production, application and toxicology of various nanomaterials. The introduction of all current nanotoxicology-related projects funded by the German Federal Ministry of Education and Research (BMBF)[1] is the second goal of DaNa. Likewise, these project results are being collected and presented recipient-friendly.

2 DaNa – general information on nanoobjects

Our aim is to provide a tool for the websites’ visitors enabling them to make responsible decisions on the opportunities and risks of nanotechnology. The presented information can be accessed via three different routes:

- Knowledge base - providing information about specific nanomaterials and applications
- Glossary - providing definitions of all relevant terms
- FAQ Section - collection of questions and answers, providing the opportunity to ask questions to the DaNa experts

The content of all published articles is presented in three levels of complexity according to the needs and interests of different recipient groups:

- Simple: interested citizens/consumers (public oriented)
- Detailed: journalists, stakeholders, scientists from other fields
- Complex: scientists from related fields, regulators

In order to complete the picture the website also provides additional information about current developments in research, news, press releases, events and conferences related to the field of nanotechnology.

2.1 DaNa knowledge base

The core and thus most important part of the DaNa web platform is its knowledge base. It contains information on the actual state of knowledge being assembled from project results (funded by the German Federal Ministry of Education and Research, BMBF), analysis of scientific publications, reports, and latest news on human and environmental toxicology. Literature providing the basis of the
The nanomaterials knowledge base is selected in accordance with quality criteria that have been acknowledged worldwide within the scientific community. A “Literature Criteria Checklist”[2] to evaluate publications has been developed by the DaNa expert team and made publicly available (see also section 2.2).

The provided detailed information regarding specific nanomaterials can be accessed either directly via the menu toolbar or by using the integrated application-based database, the so-called “slot-machine”. This database contains only information about actual applications with nanomaterials. You choose a certain application, for example lacquer and plastics additive, and you get the corresponding material(s), here cerium dioxide and many others, with brief information on exposure, uptake and behaviour (indicated by red highlighting). Starting with a specific material, you get the corresponding applications as well as facts about e.g. its behaviour in the body and in the environment. Using this playful approach a wider range of appeal for the public is generated and interested visitors are then navigated to the detailed information provided for each nanomaterial.

Figure 1 : Slot-machine: an application-based approach to map connections between application of nanoproducts, material and outcome/effects [3].

The core part of the material knowledge base is structured according to the specific nanomaterials, e.g. nano-scaled cerium dioxide, titanium dioxide or quantum dots. Each section provides general information on the nanomaterials production, usage and material properties. Furthermore, paragraphs
on human toxicology summarize the available data regarding exposure, uptake and behaviour in the body and epidemiology. Regarding exposure to nanomaterials the section takes into account the in vivo and in vitro situation whereas the uptake section focuses on the different uptake routes for nanoobjects (skin, lung, gastro-intestinal tract). Behavioural aspects are addressed relating to cells or the blood-brain barrier.

Regarding nanomaterials in the environment, the knowledge base provides information on environmental exposure and behaviour of particles in aquatic and terrestrial surroundings as well as uptake and potential risks for environmental organisms (terrestrial and aquatic, e.g. fish, daphnia, worms, plants, bacteria).

Figure 2: The Dana knowledge base presents a constantly growing number of nano-scaled materials, e.g. Carbon Black, with information on their application and toxicity aspects [3, 4].

2.2 Preparation of published data – DaNa Criteria Checklist

Our claim is to evaluate all data regarding their scientific value before publishing them on the website. But toxicological assessment of nanoobjects is quite a new scientific discipline and poses many pitfalls. For example, the testing methodology has basically been adopted from the testing of chemicals which is not always appropriate to analyse nanoobjects. Furthermore methods and procedures are often not yet standardized or normed creating difficulties for interpreting and comparing of data. In this context a study published by Hristozov et al 2012 [5] stated that in case of nano-TiO₂ only one third of all published data from various chemical databases is suitable for a thorough risk assessment. Taking into account the large amount of publications in scientific literature
their assumption was that currently the majority of published data/information deals with (eco)toxicity and less with exposure and risk estimation. Thus there is a need for a tool to facilitate this decision process. Therefore a methodology of selection, acquisition and evaluation of scientific publications was developed, including the definition of mandatory and desirable assessment criteria. A set of general (e.g. statistics, standardisation), biological (e.g. appropriate controls, dosing procedure) and physico-chemical (e.g. particle size and surface area, impurities) parameters was defined [2]. The list of criteria is accessible to all interested scientists via the DaNa website [2].

2.3 DaNa Standard Operating procedures (SOP)
In accordance with the DaNa Criteria Catalogue the need for a common format to share, compare and describe methodologies specific for nanomaterials has clearly been shown. Therefore Standard Operation Procedures (SOPs) should be a basis for future projects and publications. On the basis of careful scientific practice, the DaNa project team has compiled a SOP template to fill in which is also available via the website [6].

2.4 DaNa Frequently Asked Questions (FAQ) & Glossary
Most important questions on nanomaterials and nanotechnology are answered in this FAQ section. It also provides the opportunity to interact with the DaNa expert team directly by submitting questions via email. Answers will be given by an expert in the addressed scientific field and published on the website if considered to be of public relevance.

Due to the novelty of many aspects in nanotechnology, topic related specific terms need further explanation to improve the comprehensiveness of the articles. Therefore a glossary facilitates quick and easy location of relevant information in the articles. In alphabetic order, short descriptions of terms often used on the DaNa website like ’nanoobject’, ’zeta potential’ or ’agglomerate’ are given and linked correspondingly.

Figure 3. General information on nanoobjects presented on the DaNa website. Both the FAQ section and the Glossary provide easy access to the topic of nanotechnology and its related research [7, 8].
2.5 DaNa project presentations

Another important goal of the DaNa project is to give an overview of all nanotoxicology-related projects currently funded by the BMBF (German Federal Ministry for Education and Research) them being part of the funding actions NanoCare and NanoNature. It provides a presentation platform for the projects to illustrate with a short description the main scope and aims of each project. Furthermore project findings such as reports, publications etc. can be made available for the public also promoting exchange between the different project groups. Dissemination of project findings via the website are further supported by annual cluster meetings of all researchers involved in these projects.

Analogous to the literature used in the knowledge base all project-generated data will be evaluated with regard to their scientific value prior to publishing them in the DaNa-knowledge base and will be presented in a comprehensible way.

Figure 4. The “Projects” section lists and introduces shortly all relevant projects of the NanoCare and NanoNature cluster. The main scope of each project is presented as well as all corresponding project partners, exemplarily shown here for the project “NanoGEM” [9, 10].

3 Summary and outlook

The information provided by the DaNa website offers an easy access to the public on the topic of nanomaterials and toxicological questions for humans and the environment. Constant actualisation of the DaNa website has been achieved by continuous extensions of the knowledge base with additional materials and glossary with further relevant terms, respectively. So far the knowledge base evaluated information on 25 different nanomaterials. By 2011, over 60.000 visitors from more than 100 different countries retrieved information from the DaNa webpage and for 2012 visitor numbers are expected to be even higher. Worldwide appreciation of the website is also reflected by the international
background of the sites’ visitors, the top five countries of origin being Germany, USA, China, India and the United Kingdom. The acceptance of downloadable material (Criteria Checklist and SOP) is also validated by increasing download numbers. A first SOP derived from one of the BMBF-funded projects about “Detection and semi-Quantification of Endotoxin Contaminations in Nanoparticle Suspensions” [11] is already online available.

The project section is likewise extended according to the progress of each project. To improve the synergism between related projects, an annual cluster meeting of all project participants has been established. Sociological aspects regarding nanotechnology have also been addressed by the DaNa Project team in terms of a series of focus group discussions with advanced level pupils about nanotechnology and environmental protection – chances and risks. They will enable the pupils to form their own knowledge-based opinion on chances and risks associated with nanotechnological processes in the environmental sector. Cooperation and exchange with other dissemination organizations (databases, projects, websites) in the field of nanotechnology on national and international level are further future DaNa tasks. In turn, we will also contribute to relevant international activities (e.g. OECD programme). Citation of the DaNa website as single national database in the recent publication of the European Commissions’ “Commission Staff Working Paper”[12] and in the commentary “Focusing the research efforts”[13] also clearly demonstrates its importance and the quality of the provided data respectively. Finally, our comprehensive data collection will assist by defining knowledge gaps and hence further research needs.

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