Application and testing of risk screening tools for nanomaterial risk analysis
The field of engineered nanomaterial (ENM) risk analysis has matured significantly in the past decade. While there is a suite of new, emerging tools to evaluate ENM risks and make decisions regarding these risks, there has not yet been thorough testing of these tools. This analysis applies and tests three risk screening tools (NanoRiskCat, LICARA nanoSCAN, NanoGRID) using a common case study focused on ENMs designed for water treatment technologies, compares results generated, and highlights key lessons learned and best practices for stakeholders involved in developing and/or applying ENM risk screening tools. NanoRiskCat was found to be most useful for providing a visual aid to characterize the potential exposure and health impact profiles of the ENMs, while LICARA nanoSCAN was most useful for providing guidance on proceeding with ENM-enabled innovations. NanoGRID was helpful for characterizing data on potential ENM exposure and hazards and providing detailed guidance for subsequent laboratory-based testing. At the same time, several key challenges were identified during tool application and testing phases, ranging from minor inconveniences to more complex, foundational issues. Key lessons learned and potential best practices gleaned from this analysis include: i) risk screening tools can be used together in a complementary manner; ii) risk managers and other users should be clear on the selection of underlying data and impacts on results; iii) multidisciplinary teams are essential for tool completion; and iv) continued testing and validation of emerging risk analysis tools for ENMs is a continued research need.
Dermal transfer quantification of nanoparticles from nano-enabled surfaces

Engineered nanoparticles are used in various applications due to their unique properties, which have led to their widespread use in consumer products. Silver, titanium, and copper-based nanoparticles (NPs) are a few of the commonly used nanomaterials in surface coatings, mainly due to their biocidal, optical, or photocatalytical properties. The knowledge concerning potential dermal exposure to nanoparticles from nanoparticle-enabled surfaces is currently lacking, partly due to analytical challenges. The aim of this study is to perform dermal wiping tests on nano-enabled surfaces and characterize NP release from keyboard covers and freshly painted surfaces, in terms of mass and number concentration, as well as released particle size distribution through the use of spICP-MS. Three types of NPs were selected for method validation testing, Ag, TiO2, and CuO; and, the particle extraction from wipes was found to be efficient for Ag and CuO, but not for TiO2 particles. Thereafter, potential dermal transfer was tested by wipe sampling for two nanoAg-containing silicon keyboard covers, and wood painted with nanoCuO-containing paint. AgNP release was observed for one of the keyboard cover types, with around 5000 particles/cm² (corresponding to 0.002 ng/cm²) dislodged from the matrix after 3 wiping events. CuO NP release was 20,000 particles/cm² (0.885 ng/cm²) from the freshly painted surface, and magnitudes higher after the paint were subjected to wear, reaching 1.4 million particles/cm² (2.5 ng/cm²). The dermal transfer testing by wipe sampling and analytical approach used in this study demonstrates that wipe testing in combination with spICP-MS analysis can provide both qualitative data in terms of mass and number-based NP release, as well as particle characterization in terms of NP size distribution. Obtaining nano-specific release data can aid in providing a better understanding of dermal exposure to NPs from nano-enabled surfaces.
Identifying criteria for environmental risk assessment models at different stage-gates of nano-material/product innovation considering requirements of various stakeholders

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Occurrence, characterisation and fate of (nano)particulate Ti and Ag in two Norwegian wastewater treatment plant
Due to their widespread application in consumer products, elemental titanium (e.g., titanium dioxide, TiO2) and silver (Ag), also in nanoparticulate form, are increasingly released from households and industrial facilities to urban wastewater treatment plants (WWTPs). A seven-day sampling campaign was conducted in two full-scale WWTPs in Trondheim (Norway) employing only primary treatment. We assessed the occurrence and elimination of Ti and Ag, and conducted size-based fractionation using sequential filtration of influent samples to separate particulate, colloidal and dissolved fractions. Eight-hour composite influent samples were collected to assess diurnal variations in total Ti and Ag influx. Measured influent Ti concentrations (up to 290μgL−1) were significantly higher than Ag (<0.15–2.1μgL−1), being mostly associated with suspended solids (>0.7μm). Removal efficiencies ≥70% were observed for both elements, requiring for one WWTP to account for the high Ti content (∼2gL−1) in the flocculant. Nano- and micron-sized Ti particles were observed with scanning transmission electron microscopy (STEM) in influent, effluent and biosolids, while Ag nanoparticles were detected in biosolids only. Diurnal profiles of influent Ti were correlated to flow and pollutant concentration patterns (especially total suspended solids), with peaks during the morning and/or evening and minima at night, indicating household discharges as predominant source. Irregular profiles were exhibited by influent Ag, with periodic concentration spikes suggesting short-term discharges from one or few point sources (e.g., industry). Influent Ti and Ag dynamics were reproduced using a disturbance scenario generator model, and we estimated per capita loads of Ti (42–45mg cap−1 d−1) and Ag (0.11mg cap−1 d−1) from households as well as additional Ag load (14–22gd−1) from point discharge. This is the first study to experimentally and mathematically describe short-term release dynamics and dry-weather sources of emissions of Ti and Ag in municipal WWTPs and receiving environments.
Due to their widespread application in consumer products, elemental titanium (e.g., titanium dioxide, TiO2) and silver (Ag), also in nanoparticulate form, are increasingly released from households and industrial facilities to urban wastewater treatment plants (WWTPs). A seven-day sampling campaign was conducted in two full-scale WWTPs in Trondheim (Norway) employing only primary treatment. We assessed the occurrence and elimination of Ti and Ag, and conducted size-based fractionation using sequential filtration of influent samples to separate particulate, colloidal and dissolved fractions. Eight-hour composite influent samples were collected to assess diurnal variations in total Ti and Ag influx. Measured influent Ti concentrations (up to 290 μg L−1) were significantly higher than Ag (0.7 μm). Removal efficiencies ≥70% were observed for both elements, requiring for one WWTP to account for the high Ti content (∼2 g L−1) in the flocculant. Nano- and micron-sized Ti particles were observed with scanning transmission electron microscopy (STEM) in influent, effluent and biosolids, while Ag nanoparticles were detected in biosolids only. Diurnal profiles of influent Ti were correlated to flow and pollutant concentration patterns (especially total suspended solids), with peaks during the morning and/or evening and minima at night, indicating household discharges as predominant source. Irregular profiles were exhibited by influent Ag, with periodic concentration spikes suggesting short-term discharges from one or few point sources (e.g., industry). Influent Ti and Ag dynamics were reproduced using a disturbance scenario generator model, and we estimated per capita loads of Ti (42–45 mg cap−1 d−1) and Ag (0.11 mg cap−1 d−1) from households as well as additional Ag load (14–22 g d−1) from point discharge. This is the first study to experimentally and mathematically describe short-term release dynamics and dry-weather sources of emissions of Ti and Ag in municipal WWTPs and receiving environments.

Occurrence, characterisation and fate of (nano)particulate Ti and Ag in two Norwegian wastewater treatment plants

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Proxy Measures for Simplified Environmental Assessment of Manufactured Nanomaterials

Proxy measures have been proposed as a low-data option for simplified assessment of environmental threat given the high complexity of the natural environment. We here review studies of environmental release, fate, toxicity, and risk to identify relevant proxy measures for manufactured nanomaterials (MNMs). In total, 18 potential proxy measures were identified and evaluated regarding their link to environmental risk, an aspect of relevance, and data availability, an aspect of practice. They include socio-technical measures (e.g., MNM release), particle-specific measures (e.g., particle size), partitioning coefficients (e.g., the octanol-water coefficient), and other fate-related measures (e.g., half-life) as well as various ecotoxicological measures (e.g., 50% effect concentration). For most identified proxy measures, the link to environmental risk was weak and data availability low. Two exceptions were global production volume and ecotoxicity, for which the links to environmental risk are strong and data availability relatively decent. As proof of concept, these were employed to assess seven MNMs: titanium dioxide, cerium dioxide, zinc oxide, silver, silicon dioxide, carbon nanotubes, and graphene. The results show that none of the MNMs have both high production volumes and high ecotoxicity. Several refinements of the assessment are possible, such as higher resolution regarding the MNMs assessed (e.g., different allotropes) and different metrics (e.g., particle number and surface area). The proof of concept shows the feasibility of using proxy measures for environmental assessment of MNMs, in particular for novel MNMs in early technological development, when data is particularly scarce.

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Quantitative characterization of TiO$_2$ nanoparticle release from textiles by conventional and single particle ICP-MS

TiO$_2$ is ubiquitously present in a wide range of everyday items, both as an intentionally incorporated additive and naturally occurring constituent. It can be found in a wide range of consumer products, including personal care products, food contact materials, and textiles. Normal use of these products may lead to consumer and/or environmental exposure to TiO$_2$, possibly in form of nanoparticles. The aim of this study is to perform a leaching test and apply state-of-the-art methods to investigate nano-TiO$_2$ and total Ti release from five types of commercially available conventional textiles: table placemats, wet wipes, microfiber cloths, and two types of baby bodysuits, with Ti contents ranging from 2.63 to 1448 μg/g. Released particle analysis was performed using conventional and single particle inductively coupled plasma mass spectrometry (ICP-MS and spICP-MS), in conjunction with transmission electron microscopy (TEM), to measure total and particulate TiO$_2$ release by mass and particle number, as well as size distribution. Less than 1% of the initial Ti content was released over 24 h of leaching, with the highest releases reaching 3.13 μg/g. The fraction of nano-TiO$_2$ released varied among fabric types and represented 0–80% of total TiO$_2$ release. Particle mode sizes were 50–75 nm, and TEM imaging revealed particles in sizes of 80–200 nm. This study highlights the importance of using a multi-method approach to obtain quantitative release data that is able to provide an indication regarding particle number, size distribution, and mass concentration, all of which can help in understanding the fate and exposure of nanoparticles.

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Web of Science (2016): Impact factor 2.02
Web of Science (2016): Indexed yes
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Scopus rating (2015): CiteScore 1.97 SJR 0.568 SNIP 0.696
Web of Science (2015): Impact factor 2.101
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Web of Science (2014): Impact factor 2.184
Web of Science (2014): Indexed yes
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Quantitative human health risk assessment along the lifecycle of nano-scale copper-based wood preservatives

The use of nano-scale copper oxide (CuO) and basic copper carbonate (Cu2(OH)2CO3) in both ionic and micronized wood preservatives has raised concerns about the potential of these substances to cause adverse humans health effects. To address these concerns, we performed quantitative (probabilistic) human health risk assessment (HHRA) along the lifecycles of these formulations used in antibacterial and antifungal wood coatings and impregnations by means of the EU FP7 SUN project's Decision Support System (SUNDS, www.sunds.gd). The results from the risk analysis revealed inhalation risks from CuO in exposure scenarios involving workers handling dry powders and performing sanding operations as well as potential ingestion risks for children exposed to nano Cu2(OH)2CO3 in a scenario involving hand-to-mouth transfer of the substance released from impregnated wood. There are, however, substantial uncertainties in these results, so some of the identified risks may stem from the safety margin of extrapolation to fill data gaps and might be resolved by additional testing. Our stochastic approach successfully communicated the contribution of different sources of uncertainty in the risk assessment. The main source of uncertainty was the extrapolation from short to long-term exposure, which was necessary due to the lack of (sub)chronic in vivo studies with CuO and Cu2(OH)2CO3. Considerable uncertainties also stemmed from the use of default inter- and intra-species extrapolation factors.

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Nanotechnology and nanomaterials (NMs) have become an integrated part of our lives in the past decade, whether we realise it or not, and we have entered a phase where the early hype about the benefits of this mind-blowing technology is over.

Concerns have been raised throughout this period about the adverse impacts of NMs, and although these have previously been very loud, they are now slowly quieting down. This is not because we have resolved the challenges related to assessing and managing the risks of NMs but rather because we seem to have caught a sense of “nanorisk-immunity” where we gradually have become more and more indifferent to hearing about the potential risks of NMs.

Instead of implementing a regulatory framework tailored to NMs, the European Commission has initiated multiple reviews of state-of-the-scientific literature in regard to environmental, health and safety, and seems to be discussing the same risk assessment and regulatory challenges over and over. If history in regard to emerging risks and hazards can be used as a guide, we can now expect 15-20 years of univocal environmental, health and safety research that will not provide definitive answers but only dropwise glimpse into the true nature of the risks of NMs.

This thesis summarises the state of research and regulatory affairs within the field of nanomaterial regulation and risk assessment. Specifically, the focus is on areas of research with which I have been involved since 2009 in regard to: 1) mapping current uses of NMs in Europe, 2) understanding the limitations of existing legislation and, finally, 3) addressing the restraints of risk assessment and alternatives to risk assessment when it comes to NMs.

In order to obtain an overview of consumer products in Europe that are claimed to contain NMs or are claimed to be based on nanotechnology, we established an online inventory, The Nanodatabase (www.nanodb.dk), back in 2012 and started systematically to collect information about the proclaimed nanoproducants name, producers “nanoclaim”, country of origin, used NMs, location of the NM in the product, most likely exposure route among other. The Nanodatabase originally contained a little more than 1,200 products and now has information about more than 3,000 products. Through our research, we found that most of the products fall into the category of “Health and Fitness” and “Home and Garden”. The most used NMs are silver and titanium dioxide, but it is not possible to identify the NMs used for almost 60% of the products in the database.

The safety evaluation tool, NanoRiskCat, was developed and integrated into The Nanodatabase with the purpose of communicating what is known about the hazard and exposure potential of consumer products containing NMs. In its simplest form, the final NanoRiskCat evaluation of a specific nanomaterial in a given application can be communicated in the form of a short title describing the use of the NM and a colour code whereby the first three coloured bullets (•••) refer to the potential exposure of professional end-users, consumers and the environment – in that sequence – and the last two coloured bullets refer to the hazard potential for humans and the environment. The colours assigned to the exposure and hazard potential are green (+), yellow (+), red (+) and grey (+), corresponding to high, medium, low and unknown, respectively. A data analysis of the products in The Nanodatabase shows that for most product categories, the dominant route of exposure is dermal, and that the NanoRiskCat exposure potential as well as human and environmental hazard potential of most products is either “high (+)” or “unknown (+)”.

In order to address the potential risks of NMs and take the unique properties of NMs into account, a number of EU regulations and directives have been amended in recent years such as, for instance, the biocidal product regulation. However, the research presented in this thesis identifies three major weaknesses to the current regulation, namely how to define “nanomaterials”, threshold values and information requirements not tailored to the nanoscale and how to overcome the obstacles of chemical risk assessment applied to NMs.

The outcome of this research has led me to conclude that the fact that NMs are covered by the scope of existing legislation is not enough to ensure the protection of human health and the environment. We therefore need a new regulatory framework tailored for NMs and their applications. A proposal of such a framework termed “Registration, Evaluation, Authorisation, Categorisation and Tools to Evaluate Nanomaterials – Opportunities and Weaknesses (REACT NOW)” is proposed and presented herein.

The thesis consists of nine chapters. An introduction is provided in chapter 1. In chapter 2, what is known about the current uses of NMs is presented in detail, and it is established that there is a general lack of data and access to data on, for example, production volumes and uses of NMs which hampers qualitative and quantitative occupational, consumer and environmental exposure assessment of NMs – and this in turn impedes the completion of any kind of risk assessment. The latter has repetitively led to questions being raised by politicians, NGOs, academics and members of the public about whether current regulatory frameworks are up to the job, as many of them rely heavily on, for instance, the completion of meaningful risk assessments.

Chapter 3 is devoted to an analysis of the revisions that have been made to existing regulatory frameworks, such as REACH, BPR and food legislation, whereas Chapter 4 is allocated to an evaluation of proposed revisions made by a number of EU member states and REACH competent authorities such as German UBA, BfR and BAuA and the Swedish KEMI, as well as the NGOs CIEL, ClientEarth and BUND. It is concluded that the revisions that have been implemented for existing EU legislation and the proposed revisions by UBA, BfR and BAuA, KEMI and CIEL, ClientEarth and BUND collectively provide a lot of opportunities. However, a number of weaknesses have also been identified and these are elaborated on and discussed in Chapter 5, as they continue to dog the effective regulation of NMs and still need to be addressed.

In recognition of the challenges that traditional chemical risk assessments entail, and outstanding scientific research questions that still need to be resolved, no less than 50 alternative decision-support tools, or supplements to traditional
risk assessments, have been explored and proposed in recent years. These are analysed in Chapter 6, in order to identify tools that could potentially be used to support a new regulatory framework tailored specifically for NMs and their applications throughout the life cycle. This evaluation is based on a series of recent scientific publications which provide substantial reviews of these alternative tools applied in regard to risk governance, worker protection, consumer exposure, environmental assessment, waste, etc. This led to the realisation that we need a tool that is both regulatory-relevant and can be applied despite the lack of data and lack of access to information.

Safety evaluation plays a key role in REACT NOW and the safety evaluation tool NanoRiskCat developed by Hansen et al. (2014, 2017c) is presented in detail in chapter 7. A strength of NanoRiskCat is that it has been applied to more than 2,000 products claimed to include NMs or to be based on nanotechnology. The outcome of this is presented in this thesis. Finally, in Chapter 6, REACT NOW is introduced and key components of the framework are outlined.

As part of REACT NOW, I recommend that manufacturers and importers of NMs should be required to register their NM(s) prior to commercialisation and independent of production and import volumes. For NM(s) already being sold, manufacturers and importers should be required to register and fulfil the REACT NOW requirements within a certain time period e.g. six months of the adoption of the framework. NMs are defined according to SCENIHR’s definition and not the one recommended by the EC. Primary particle size distribution, shape (including aspect ratio), specific surface area and surface treatment are considered “identifiers” and not the “characterisers” as suggested by UBA, BfR and BAuA (2013). In practice, this means that any variation in size, shape, surface area and surface-treated NM that is commercialised in the EU has to be identified, named and safety-evaluated separately, before it is placed into a separate registration dossier.

The European Chemicals Agency is identified as the European authority that should be responsible for the management and carrying out the technical and administrative aspects of REACT NOW, however the burden of proof of safety should be placed on industry to ensure that data are generated in good time. In order to ensure the protection of health and the environment, I recommend that the registrant should be required to explain a relevant product’s functional use, provide justification for its use and carry out an effectiveness evaluation prior to the commercialisation of any nanomaterial.

Following the requirements of REACT NOW, all uses of NMs have to be evaluated according to NanoRiskCat. The health and environmental hazard information required as part of the information requirements focuses on enabling the application of NanoRiskCat. In regard to human health it includes High Aspect Ratio Nanoparticles (HARN), bulk CLP classification, acutely toxicity, genotoxicity and mutagenicity, carcinogenicity and respiratory toxicity. For the environment, it includes bulk CLP classification, aquatic toxicity, freshwater tests for degradation, bioaccumulation and a scientific review in regard to dispersive or long-range transport, ecosystem effects and novelty. It is important to note that NanoRiskCat uses a tiered approach and that the registrant only has to submit enough information to enable the categorisation of the health and environmental hazard potential of the specific NM into high (+), medium (+), low (+) or unknown (+). Depending on the outcome of the NanoRiskCat evaluation, manufacturers and importers of NMs and producers of NM products might have to seek authorisation, which can only be given for specific uses of NMs and nanoproducts that are deemed necessary, efficient and have a functional use. For NMs that have undergone a NanoRiskCat evaluation and have 1) a red professional end-user and/or a consumer exposure profile combined with a red human health hazard profile and/or 2) a red environmental exposure profile combined with a red environmental hazard profile, the registrant is required to complete an “Alternatives Assessment” and the agency responsible for REACT NOW is required to seek opinion on safe use from the European scientific committee of relevance. In such cases, authorisation should be granted, but only if the specific use under consideration is deemed safe and necessary.

Uses of NMs deemed not to be safe by the scientific committees e.g. dispersive uses of HARN, indoor consumer uses of spray products with NMs associated with respiratory toxicity, should not be granted authorisation and should not be given permission to be marketed in Europe. For all other combinations of exposure and hazard profiles, i.e. NanoRiskCat categories 2-4, the agency responsible for REACT NOW can ask for an opinion from the scientific committees of relevance on a case-by-case basis.

As a general rule, authorisation should only be given for specific professional end-user and consumer applications of NMs and nanoproducts, if they have a green human health hazard profile combined with a green professional end-user exposure profile and a consumer exposure profile, respectively. The same goes for uses that are expected to lead to environmental exposure that should only be granted authorisation if the NM in question has a green environmental hazard profile.

Should the agency or the scientific committees have questions about the safety of a given NM and its specific use, the agency can make a request for additional information, to be generated within 3 years, within which time conditional authorisation can be granted.

For combinations of yellow exposure and hazard profiles, conditional authorisation is possible for a time-limited period during which time the agency should request the generation of additional information by the registrant. In order to assist industry and especially Small and Medium-sized Enterprises in the process of implementing REACT NOW, technical and non-technical assistance is needed and should be provided by the European Commission Joint Research Centre and the European Chemicals Agency.

REACT NOW is the first attempt to present a comprehensive and transparent decision-making framework tailored to regulate the use of NMs, but as no framework is without either potential or limitations, the opportunities and weaknesses related to the implementation of REACT NOW are pinpointed. Strengths include that NanoRiskCat can be used despite lack of data and information, whereas the lack of clear-cut definitions of “necessity” and “effectiveness” could be considered a weakness along with the arguably crude exposure assessment in NanoRiskCat.

In the appendix, the 28 peer reviewed journal papers on which this thesis is based are included. It is worth pointing out that most of the topics briefly discussed and presented in Chapters 2-8 are detailed in the journal papers and that this thesis is written to present REACT NOW and to give the reader an overview of the original achievements of the work.
Revising REACH technical guidance on information requirements and chemical safety assessment for engineered nanomaterials for aquatic ecotoxicity endpoints - recommendations from the EnvNano project

The difficulties in establishing an occupational exposure limit for carbon nanotubes

Concern over the health effects from the inhalation of carbon nanotubes (CNTs) has been building for some time, and adverse health effects found in animal studies include acute and chronic respiratory damage, cardiac inflammation, and cancer including mesothelioma, heretofore only associated with asbestos exposure. The strong animal evidence of toxicity requires that the occupational hygiene community develops strategies for reducing or eliminating worker exposures to CNTs; part of this strategy involves the setting of occupational exposure limits (OELs) for CNTs. A number of government agencies and private entities have established OELs for CNTs; some are mass-based, while others rely on number concentration. We review these various proposed standards and discuss the pros and cons of each approach. We recommend that specific action be taken, including intensified outreach to employers and employees concerning the potential adverse health effects from CNT inhalation, the development of more nuanced OELs that reflect the complex nature of CNT exposure, a broader discussion of these issues among all interested parties, and further research into important unanswered questions including optimum methods to evaluate CNT exposures. We conclude that current animal toxicity evidence suggests that strong action needs to be taken to minimize exposures to CNTs, and that any CNT OEL should be consistent with the need to minimize exposures.
The ten decrees of nanomaterials regulations
The new revisions of the Annexes of the European Union's chemical legislation with regards to nanomaterials will provide more structure and clarity, but they will also force manufacturers, importers and downstream users to put substantial effort into understanding the details of what should and should not be done.

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A Critical Analysis of the Environmental Dossiers from the OECD Sponsorship Programme for the Testing of Manufactured Nanomaterials

In 2015, the OECD finally published the findings of its seven year testing programme for manufactured nanomaterials. Here, we present the first in-depth analysis of the published OECD dossiers with regards to data on physical and chemical properties, environmental fate and ecotoxicology. Each individual study in the dossiers was reviewed with regard to, among other, which OECD Test Guidelines (TG) were used, and the reliability assigned to the study. We furthermore analyzed in detail the suspension methods used, how media quality was quantified and physical and chemical characterization performed prior, during and/or at the end of the study. We find that the information in the dossiers present an incomplete portfolio of nanomaterial ecotoxicological evaluations that are difficult to draw substantive conclusions from and that most of the studies were not designed to investigate the validity of the OECD Test Guidelines. We acknowledge the effort of the OECD WPMN and recommend that a follow-on program is established with well-defined goals, end-points and direct funding to qualified research laboratories to ensure valid, rigorous, reproducible and efficient research.

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Contributors: Hansen, S. F., Pelsy, F., Broomfield, M., Kobe, A.
Number of pages: 1
Publication date: 2017

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Title of host publication: Book of Abstracts, Sustain 2017
Publisher: Technical University of Denmark (DTU)
Article number: U-9
Electronic versions:
SustainAbstracts2017c.compressed_175.pdf
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Correction to Development of Comparative Toxicity Potentials of TiO₂ Nanoparticles for Use in Life Cycle Assessment

General information
State: Published
Organisations: Quantitative Sustainability Assessment, Department of Environmental Engineering, Environmental Chemistry, Department of Management Engineering, Technical University of Denmark, Quantis, Radboud University Nijmegen
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BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.58 SJR 2.535 SNIP 1.941
Web of Science (2017): Impact factor 6.653
Web of Science (2017): Indexed yes
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<td>SJR 3.03 SNIP 2.315</td>
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Development of Comparative Toxicity Potentials of TiO₂ Nanoparticles for Use in Life Cycle Assessment

Studies have shown that releases of nanoparticles may take place through the life cycle of products embedding nanomaterials, thus resulting in potential impacts on ecosystems and human health. While several life cycle assessment (LCA) studies have assessed such products, only a few of them have quantitatively addressed the toxic impacts caused by released nanoparticles, thus leading to potential biases in their conclusions. Here, we address this gap and aim to provide a framework for calculating characterization factors or comparative toxicity potentials (CTP) for nanoparticles and derive CTP values for TiO₂ nanoparticles (TiO₂-NP) for use in LCA. We adapted the USEtox 2.0 consensus model to integrate the SimpleBox4Nano fate model, and we populated the resulting model with TiO₂-NP specific data. We thus calculated CTP values for TiO₂ nanoparticles for air, water, and soil emission compartments for freshwater ecotoxicity and human toxicity, both cancer effects and noncancer effects. Our results appeared plausible after benchmarking with CTPs for other nanoparticles and substances present in the USEtox database, while large differences were observed with CTP values for TiO₂ nanoparticles published in earlier studies. Assumptions, which were performed in those previous studies because of lack of data and knowledge at the time they were made, primarily explain such discrepancies. For future assessment of potential toxic impacts of TiO₂ nanoparticles in LCA studies, we therefore recommend the use of our calculated CTP.

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Department of Management Engineering, Quantitative Sustainability Assessment, Technical University of Denmark, Quantis, Radboud University Nijmegen
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.58 SJR 2.535 SNIP 1.941
Web of Science (2017): Impact factor 6.653
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.26 SJR 2.559 SNIP 1.902
Web of Science (2016): Impact factor 6.198
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.61 SJR 2.546 SNIP 1.838
Web of Science (2015): Impact factor 5.393
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.5 SJR 2.777 SNIP 2.003
Ecotoxicity testing of nanoparticles - The quest for disclosing the nano-effect

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Baun, A., Skjolding, L. M., Sørensen, S. N., Hjorth, R., Hansen, S. F., Hartmann, N. B.
Pages: 48-48
Publication date: 2017

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Place of publication: Elsinore, Denmark
Publisher: National research centre for the working environment
Electronic versions:
Nanotech_symp_Ecotoxicity.pdf
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Erratum to: NanoRiskCat: a conceptual tool for categorization and communication of exposure potentials and hazards of nanomaterials in consumer products

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, National Research Centre for the Working Environment
Contributors: Hansen, S. F., Jensen, K. A., Baun, A.
Number of pages: 3
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Peer-reviewed: Yes

Publication information
Journal: Journal of Nanoparticle Research
Volume: 19
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Article number: 236
ISSN (Print): 1388-0764
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Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.93 SJR 0.528 SNIP 0.603
Web of Science (2017): Impact factor 2.127
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.496 SNIP 0.557
Web of Science (2016): Impact factor 2.02
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.97 SJR 0.568 SNIP 0.696
Web of Science (2015): Impact factor 2.101
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.17 SJR 0.672 SNIP 0.861
Web of Science (2014): Impact factor 2.184
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.54 SJR 0.753 SNIP 1.01
Web of Science (2013): Impact factor 2.278
Plastic pollution and its environmental effects has received global attention the recent years. However, limited attention has so far been directed towards how plastics are regulated in a life cycle perspective and how regulatory gaps can be addressed in order to limit and prevent environmental exposure and hazards of macro- and microplastics. In this paper, we map European regulation taking outset in the life cycle perspective of plastic carrier bags: from plastic bag production to when it enters the environment. Relevant regulatory frameworks, directives and authorities along the life cycle are identified and their role in regulation of plastics is discussed. Most important regulations were identified as: the EU chemical Regulation, the Packaging and Packaging Waste Directive including the amending Directive regarding regulation of the consumption of lightweight plastic carrier bags, the Waste Framework Directive and the Directive on the Landfill of Waste. The main gaps identified relate to lack of clear definitions of categories of polymers, unambitious recycling rates and lack of consideration of macro- and microplastics in key pieces of legislation. We recommend that polymers are categorized according to whether they are polymers with the same monomer constituents (homopolymers) or with different monomer constituents (copolymers) and that polymers are no longer exempt from registration and evaluation under REACH. Plastics should furthermore have the same high level of monitoring and reporting requirements as hazardous waste involving stricter requirements to labelling, recordkeeping, monitoring and control over the whole lifecycle. Finally, we recommend that more ambitious recycle and recovery targets are set across the EU. Regulation of the consumption of lightweight plastic carrier bags should also apply to heavyweight plastic carrier bags. Last, the Marine and Water Framework Directives should specifically address plastic waste affecting water quality.
Goodness of dustiness index for predicting human exposure to airborne nanomaterials

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, National Research Centre for the Working Environment, Institute of Occupational Medicine (IOM)
Number of pages: 1
Publication date: 2017

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Title of host publication: New tools and approaches for nanomaterial safety assessment - book of abstracts
Place of publication: Malaga, Spain
Article number: #1552
Electronic versions:
BOOK_OF_ABSTRACTS
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Identifying criteria for environmental risk assessment models at different stagegates of nano-material/product innovation considering requirements of various stakeholders

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Pages: 145-145
Publication date: 2017

Host publication information
Title of host publication: Abstracts - 8th international symposium on nanotechnology, occupational and environmental health
Place of publication: Elsinore, Denmark
Meeting the needs for released nanomaterials required for further testing - the sun approach

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Environmental Chemistry, Swiss Federal Laboratories for Materials Science and Technology (Empa), RWTH Aachen University, University of Vienna
Number of pages: 1
Publication date: 2017

Host publication information
Title of host publication: New tools and approaches for nanomaterial safety assessment - book of abstracts
Place of publication: Malaga, Spain
Article number: #1515
Electronic versions:
BOOK_OF_ABSTRACTS
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Occurrence, characterisation and fate of (nano)particulate Ti and Ag in two Norwegian wastewater treatment plants

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, SINTEF
Contributors: Polesel, F., Farkas, J., Kjos, M., Hansen, S. F., Plösz, B. G., Booth, A. M.
Number of pages: 2
Publication date: 2017
Peer-reviewed: Yes
Electronic versions:
Ti_Ag_Trondheim_WWTPs_abstract_FABP_FINAL.pdf
Source: PublicationPreSubmission
Source-ID: 132146256
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2017

React now regarding nanomaterial regulation
The time has come to implement a regulatory framework tailored to manufactured materials. I propose a new legislative framework that combines registration, evaluation, authorization and categorization of nanomaterials.

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Hansen, S. F.
Number of pages: 3
Pages: 714-716
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Nature Nanotechnology
Volume: 12
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ISSN (Print): 1748-3387
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
Readiness of control banding tools for safe innovation and regulatory occupational exposure assessment of nanomaterials
Revising REACH guidance on information requirements and chemical safety assessment for engineered nanomaterials for aquatic ecotoxicity endpoints: recommendations from the EnvNano project

The European Chemical Agency (ECHA) is in the process of revising its guidance documents on how to address the challenges of ecotoxicological testing of nanomaterials. In these revisions, outset is taken in the hypothesis that ecotoxicological test methods, developed for soluble chemicals, can be made applicable to nanomaterials. European Research Council project EnvNano—Environmental Effects and Risk Evaluation of Engineered, which ran from 2011 to 2016, took another outset by assuming that: “The behaviour of nanoparticles in suspension is fundamentally different from that of chemicals in solution”. The aim of this paper is to present the findings of the EnvNano project and through these provide the scientific background for specific recommendations on how ECHA guidance could be further improved. Key EnvNano findings such as the need to characterize dispersion and dissolution rates in stock and test media have partially been addressed in the updated guidance. However, it has to be made clear that multiple characterization methods have to be applied to describe state of dispersion and dissolution over time and for various test concentration. More detailed information is called for on the specific characterization methods and techniques available and their pros and cons. Based on findings in EnvNano, we recommend that existing algal tests are supplemented with tests where suspensions of nanomaterials are aged for 1–3 days for nanomaterials that dissolve in testing media. Likewise, for daphnia tests we suggest to supplement with tests where (a) exposure is shortened to a 3 h pulse exposure in daphnia toxicity tests with environmentally hazardous metal and metal oxide nanomaterials prone to dissolution; and (b) food abundance is three to five times higher than normal, respectively. We further suggest that the importance of considering the impact of shading in algal tests is made more detailed in the guidance and that it is specified that determination of uptake, depuration and trophic transfer of nanomaterials for each commercialized functionalization of the nanomaterials is required. Finally, as an outcome of the project a method for assessing the regulatory adequacy of ecotoxicological studies of nanomaterials is proposed.
Risk Perception of Plastic Pollution: Importance of Stakeholder Involvement and Citizen Science

Risk perception has a significant impact on how society reacts to a given risk. There have been cases where a mismatch between the actual risk and the perception of it has led to poor decisions on societal initiatives, such as inappropriate regulatory measures. It is therefore important that the perception of risk is based on an informed foundation acknowledging the biases and drivers that inevitably go with risk perception. Plastic pollution differs in regard to other classical risks, such as those posed by chemicals or genetically modified organisms (GMOs), since the pollution is more visible and already has a significant magnitude. At the same time, everyone is familiar with using plastic, and our daily lives are highly dependent on the use of plastic. This offers some potential to strengthen the societal risk perception and subsequently implement effective measures to address the pollution.

In this chapter, we define eight risk perception drivers (voluntariness, control, knowledge, timing, severity, benefit, novelty, and tangibility) and relate these drivers to plastic pollution. We discuss the process in which plastic pollution has been recognized as an important environmental problem by scientists, the public, and policy makers and elaborate on how the eight risk drivers have influenced this process. Plastic pollution has several of the characteristics that can enhance people’s perception of the risk as being important and which has generated great awareness of the problem. The chapter finally discusses how risk perception can be improved by greater stakeholder involvement and utilization of citizen science and thereby improve the foundation for timely and efficient societal measures.

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Roskilde University
Contributors: Syberg, K., Hansen, S. F., Christensen, T. B., Khan, F.
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Pages: 203-221
Publication date: 2017

Host publication information
Title of host publication: Freshwater Microplastics - Emerging Environmental Contaminants?
Publisher: Springer
Editors: Wagner, M., Lambert, S.
Teaching nanosafety

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Hansen, S. F., Baun, A.
Number of pages: 1
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Peer-reviewed: Yes

Publication information
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Volume: 12
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Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 25.47 SJR 20.612 SNIP 8.171
Web of Science (2017): Impact factor 37.49
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 21.85 SJR 18.916 SNIP 7.649
Web of Science (2016): Impact factor 38.986
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 22.1 SJR 18.842 SNIP 8.019
Web of Science (2015): Impact factor 35.267
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BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 21.76 SJR 17.177 SNIP 8.047
Web of Science (2014): Impact factor 34.048
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 21.94 SJR 16.688 SNIP 7.784
Web of Science (2013): Impact factor 33.265
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 17.55 SJR 15.706 SNIP 7.569
Web of Science (2012): Impact factor 31.17
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
The applicability of chemical alternatives assessment for engineered nanomaterials

The use of alternatives assessment to substitute hazardous chemicals with inherently safer options is gaining momentum worldwide as a legislative and corporate strategy to minimize consumer, occupational, and environmental risks. Engineered nanomaterials represent an interesting case for alternatives assessment approaches as they can be considered both emerging “chemicals” of concern, as well as potentially safer alternatives to hazardous chemicals. However, comparing the hazards of nanomaterials to traditional chemicals or to other nanomaterials is challenging and critical elements in chemical hazard and exposure assessment may have to be fundamentally altered to sufficiently address nanomaterials. The aim of this paper is to assess the overall applicability of alternatives assessment methods for nanomaterials and outline recommendations to enhance their use in this context. This paper focuses on the adaptability of existing hazard and exposure assessment approaches to engineered nanomaterials as well as strategies to design inherently safer nanomaterials. We argue that alternatives assessment for nanomaterials is complicated by the sheer number of nanomaterials possible. As a result, the inclusion of new data tools that can efficiently and effectively evaluate nanomaterials as substitutes are needed to strengthen the alternatives assessment process. However, we conclude that with additional tools to enhance traditional hazard and exposure assessment modules of alternatives assessment, such as the use of mechanistic toxicity screens and control banding tools, alternatives assessment can be adapted to evaluate engineered nanomaterials both as potential substitutes for chemicals of concern and to ensure safer nanomaterials are incorporated in the design of new products. This article is protected by copyright. All rights reserved.
The release of silver nanoparticles from commercial toothbrushes

The use of silver nanoparticles (NPs) in commercial products has become increasingly common in the past decade, mostly due to their antimicrobial properties. Using Ag NP-containing articles may lead to particle release, which raises concern of human and environmental safety. The published literature addressing particle release is scarce, especially when it comes to quantifying exposure to NPs specifically. In this study, we have experimentally investigated the release of total Ag and Ag NP from commercially available toothbrushes i.e. biodegradable toothbrushes for adults and toothbrushes for children. Toothbrushes were immersed and abraded in tap water for 24 h corresponding to more than the whole intended usage time of a toothbrush. The total amount of released Ag was quantified by inductively coupled plasma-mass spectrometry (ICP-MS) analysis, and the Ag NPs were characterized by single particle ICP-MS and transmission electron microscopy (TEM). The median size of the released Ag NPs ranged from 42 to 47 nm, and the maximum total Ag release was 10.2 ng per toothbrush. The adult toothbrushes were generally releasing more total Ag and NPs than children toothbrushes. In conclusion, our results indicate that the use of Ag NP-impregnated toothbrushes can cause consumer as well as environmental exposure to Ag NPs.

General information
The Role of Alternative Testing Strategies in Environmental Risk Assessment of Engineered Nanomaterials

Within toxicology there is a pressure to find new test systems and organisms to replace, reduce and refine animal testing. In nanoecotoxicology the need for alternative testing strategies (ATS) is further emphasized as the validity of tests and risk assessment practices developed for dissolved chemicals are challenged. Nonetheless, standardized whole organism animal testing is still considered the gold standard for environmental risk assessment. Advancing risk analysis of engineered nanomaterials (ENMs) through ATS was discussed in September 2014 at an international Society for Risk Analysis (SRA) workshop in Washington, D.C. and serves as the point of departure for this paper. Here we present the main outcomes by describing and defining the use of ATS for ENMs as well as discussing its future role in environmental risk science. We conclude that diversity in testing should be encouraged to avoid “selective ignorance” and that, through an iterative process with low-tier and high-tier testing, data-generation can be validated to ensure relevant endpoints. Furthermore, simplified screening of ENMs could enable early decision-making on material design, while complex multispecies studies should be utilized to skip uncertain environmental extrapolations and give rise to more accurate risk analysis.

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, University of California, University of Montana, RTI International, Duke University
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Pages: 293-301
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Environmental Science: Nano
Volume: 4
ISSN (Print): 2051-8153
Ratings:
The sun tiered modeling-based inhalation, dermal, oral and inadvertent oral exposure assessment framework for nanomaterials

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, National Research Centre for the Working Environment, Tampere University of Technology, Institute of Occupational Medicine (IOM)
Number of pages: 2
Publication date: 2017

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Place of publication: Malaga, Spain
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Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2017

Acute toxicity of sea-dumped chemical munitions: Luminating the environmental toxicity of legacy compounds
As a result of the disarmament of Germany after the Second World War, 65,000 tons of chemical munitions were dumped in the Baltic Sea. Approximately 13,000 tons containing chemical warfare agents (CWAs) of which 11,000 tons were dumped in the Bornholm Basin east of Bornholm. This paper addresses the ecotoxicity of compounds actually present in the Bornholm dumpsite by obtaining novel acute ecotoxicity data. EC50 values were successfully obtained for 12 CWAs from acute tests using Allivibrio fischeri (Microtox™). The three most toxic compounds were α-chloroacetophenone, 2-chlorovinylarsonic acid and 1,2,5-trithiepane having EC50 values of 11.20, 31.20 and 1170 μg L−1, respectively. A. fischeri demonstrated hormesis when exposed to triphenylarsine and triphenylarsine oxide at concentrations of 100 and 50 mg L−1, respectively. Four different mixtures were assessed including compounds which were dissolvable, a mixture of sulphur mustard degradation products, a mixture of the three most toxic sulphur mustard compounds, a mixture of organoarsenical degradation products and a mixture of all compounds. The mixtures deviate by a factor of 1.5–2.5 from...
the prediction of the concentration addition model and hence, the mixtures demonstrate no sign of synergism or antagonism. The compounds presented in this study are mainly CWA.

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Technical University of Denmark, Aarhus University
Contributors: Mohammed Abdullah Christensen, I., Sanderson, H., Baatrup, E., Storgaard, M. S., Fauser, P., Hansen, S. F.
Pages: 39-50
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Peer-reviewed: Yes

Publication information
Volume: 1
Issue number: 1
ISSN (Print): 2377-9497
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Electronic versions:
Christensen_et_al_2016_Sea_dumped_chemicals_.pdf
DOIs:
10.1080/23779497.2016.1219962
Source: FindIt
Source-ID: 2341877482
Research output: Research - peer-review › Journal article – Annual report year: 2016

Advancing Alternative Analysis: Integration of Decision Science
Decision analysis—a systematic approach to solving complex problems—offers tools and frameworks to support decision making that are increasingly being applied to environmental challenges. Alternatives analysis is a method used in regulation and product design to identify, compare, and evaluate the safety and viability of potential substitutes for hazardous chemicals. Assess whether decision science may assist the alternatives analysis decision maker in comparing alternatives across a range of metrics.

A workshop was convened that included representatives from government, academia, business, and civil society and included experts in toxicology, decision science, alternatives assessment, engineering, and law and policy. Participants were divided into two groups and prompted with targeted questions. Throughout the workshop, the groups periodically came together in plenary sessions to reflect on other groups’ findings.

We conclude the further incorporation of decision science into alternatives analysis would advance the ability of companies and regulators to select alternatives to harmful ingredients, and would also advance the science of decision analysis. We advance four recommendations: (1) engaging the systematic development and evaluation of decision approaches and tools; (2) using case studies to advance the integration of decision analysis into alternatives analysis; (3) supporting transdisciplinary research; and (4) supporting education and outreach efforts.

General information
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Organisations: Department of Environmental Engineering, Environmental Chemistry
Number of pages: 53
Publication date: 2016
Peer-reviewed: Yes

Publication information
Journal: Environmental Health Perspectives
ISSN (Print): 0091-6765
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Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.07 SJR 3.41 SNIP 2.351
Aquatic Ecotoxicity Testing of Nanoparticles—The Quest To Disclose Nanoparticle Effects
The number of products on the market containing engineered nanoparticles (ENPs) has increased significantly, and concerns have been raised regarding their ecotoxicological effects. Environmental safety assessments as well as relevant and reliable ecotoxicological data are required for the safe and sustainable use of ENPs. Although the number of publications on the ecotoxicological effects and uptake of ENPs is rapidly expanding, the applicability of the reported data for hazard assessment is questionable. A major knowledge gap is whether nanoparticle effects occur when test organisms are exposed to ENPs in aquatic test systems. Filling this gap is not straightforward, because of the broad range of ENPs and the different behavior of ENPs compared to “ordinary” (dissolved) chemicals in the ecotoxicity test systems. The risk of generating false negatives, and false positives, in the currently used tests is high, and in most cases difficult to assess. This Review outlines some of the pitfalls in the aquatic toxicity testing of ENPs which may lead to misinterpretation of test results. Response types are also proposed to reveal potential nanoparticle effects in the aquatic test organisms.

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State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, National Food Institute
Contributors: Skjolding, L. M., Sørensen, S. N., Hartmann, N. B., Hjorth, R., Hansen, S. F., Baun, A.
Number of pages: 16
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Over the last decade the number of products on the market containing engineered nanoparticles (ENPs) has increased significantly and concerns have been raised regarding the potential for ecotoxicological effects of ENPs. To promote safe and sustainable use of ENPs, environmental safety assessments are needed and for this purpose relevant and reliable ecotoxicological data is demanded. While the literature on ecotoxicological effects and uptake of ENPs is rapidly expanding, the applicability of reported data of ENPs for hazard assessment purposes is questionable. A major knowledge gap is whether nanoparticle effects occur when test organisms are exposed to ENPs in aquatic test systems. This knowledge gap is not straightforward to fill, due to the high variability in ENP types, and the different behavior of ENPs compared to "ordinary" (dissolved) chemicals in the ecotoxicity test systems. The risk of generating false negative, as well as false positive, results in the currently used tests is high, but in most cases difficult to assess. This literature review outlines some of the pitfalls in aquatic toxicity testing of ENPs which may lead to misinterpretation of test results. Furthermore, the review proposes response types to account for in order to reveal potential nanoparticle effects in the aquatic test organisms used for risk assessments of ENPs.
Control banding tools for occupational exposure assessment of nanomaterials - Ready for use in a regulatory context?
The development, production and application of engineered nanomaterials are becoming more and more widespread. Because researchers, developers and industrial workers are the first in line to be exposed to potentially hazardous nanomaterials, appropriate occupational exposure assessment is a key area of concern. Therefore, a number of Control Banding (CB)-based tools have been developed in order to assess and manage the potential risks associated with occupational exposure to nanomaterials. In this paper we provide a comparative analysis of different nanomaterial-specific types of control-banding/risk prioritization tools (the Control Banding Nanotool, IVAM Technical Guidance, Stoffenmanager Nano, ANSES CB Tool, NanoSafer, and the Precautionary Matrix) in order to evaluate their use-domains; types, extent, use and availability of input parameters; their output format; and finally their potential use and maturity in regard to meeting the minimum requirements for occupational exposure assessment under REACH and the conceptual source-transmission-receptor model by Schneider et al. (2011). This was done through an analysis including a literature review and use of the tools. It was found that the tools were developed for different purposes, with different application domains and inclusion criteria. The exposure assessments and derived risk levels are based on different concepts and assumptions and outputs in different formats. The use of requested input parameters for exposure assessment differ greatly among the tools. Therefore, direct inter-comparison and combination of the different models into a larger holistic framework is not immediately possible. Harmonization of input parameters and output could allow establishment of an exposure assessment framework with different levels of information requirements.

Current uses of nanomaterials in biocidal products and treated articles in the EU
Nanomaterials (NMs) are currently being used for a wide variety of products, and a number of them are utilized as biocides due to their antimicrobial or antifungal properties. Little is known to what extent these biocides are available on the market as consumer products. In the EU, the Biocidal Product Regulation (BPR) lays out a list of requirements that
manufacturers of biocidal products have to comply with before they can place their products on the market. It is not entirely clear which commercially available articles in the EU have been treated with or incorporate NMs to provide biocidal properties to the product. To obtain an insight into what biocidal products are on the EU market, we used The Nanodatabase (nanodb.dk) for analyzing which NMs are being used and what product categories they represent. In this paper, we address the issue of the current uses of NMs in biocidal products and discuss how they are currently regulated under the BPR. Even though the BPR already entails nanospecific provisions, correct labelling of biocidal products containing NMs is virtually non-existent. By using The Nanodatabase, it was possible to identify 88 biocidal products containing NMs available on the EU market, none of which had the specific labelling required by the BPR. The analysis of biocidal products pinpoints the challenges and limitations for obtaining a reasonable overview of the current uses of NMs in biocidal products as defined in the BPR.

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Environmental risk assessment and management of engineered nanomaterials - The role of ecotoxicity testing
In 2004, the first article on ecotoxicity of engineered nanomaterials (ENMs) was published, subsequently giving birth to the field of nanoecotoxicity. Today, approximately a thousand peer-reviewed articles have been published on the topic albeit many challenges remain within the field. Central to these is the continued examination of the applicability of ecotoxicity testing to encompass the testing of particles, as the tests originally are developed for dissolved chemicals. Furthermore,
the ability of such testing to inform environmental risk assessment and environmental risk management, including the applicability of these concepts, has been questioned.

The present thesis provides an overview of the challenges facing ecotoxicity testing of ENMs and investigates whether we can rely on such testing to inform risk assessment and eventually management of the potential environmental risk of ENMs.

Although the Organisation for Economic Co-operation and Development (OECD) launched a seven-year-long testing programme around the use of standardized OECD test guidelines (TGs) for ENMs, which concluded that the TGs are generally applicable to ENMs, this thesis argues that it is not possible to offer any conclusions based on their analysis. Efforts within nanotoxicology are focused on modifying existing TGs to improve the stability and dispersion of suspended ENMs, although it is paramount to acknowledge that the underlying assumption of the dissolved nature of the test compound is violated. Furthermore, several dilemmas - so-called double binds - should also be acknowledged as they dictate the limitations of standardization and therefore also its ability to guide risk assessment.

The paradigm of conducting in vivo animal toxicity testing and extrapolating the data to either humans or the environment is gradually being replaced with a focus on in silico and in vitro studies with an even greater need for and reliance on extrapolation. However, in this thesis it is argued that within ecotoxicity, whole organism models remain at the foundation of environmental risk assessment, and as such, they are likely to remain in use for nanotoxicology. Indeed, the use of more complex in vivo systems such as microcosms and mesocosms are recommended to enable and validate current risk assessment practices. But just as envisioned in human toxicology, an integrated approach must be pursued to reap the benefits of simplified as well as more complex testing systems, each fit for purpose for different tasks.

It is concluded that it is not possible to conduct environmental risk assessment of ENMs with a satisfactory level of certainty, primarily due to knowledge gaps and the uncertainty imbedded in current ecotoxicity data. Albeit with time better data will be available, it is important that tools encompassing uncertainty are utilized to facilitate decision-support. As the risk constituted by ENMs cannot be quantified, the use, need and ability of risk management options to encompass the potential risk are similarly challenged. This should invoke a precautionary stance on the use of ENMs.

Within the field of nanotoxicology the concept of creating ‘safety by design’ has received much attention, arguably both due to these risk assessment and management issues, but also in spite of them. Instead of focusing on managing complexity and uncertainty, the rise of ‘safety by design’ indicates that the field is going towards a more deterministic approach with a misplaced promise to solve these management issues scientifically.

Finally, identifying risky ENMs and safer alternatives through alternatives assessment should be encouraged. Importantly, in doing so we will also be forced to look at risk in combination with benefits, as addressing risk in isolation rarely leaves room for resolving societal issues.

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Environmental risk assessment of chemicals and nanomaterials — The best foundation for regulatory decision-making?
Environmental risk assessment (ERA) is often considered as the most transparent, objective and reliable decision-making tool for informing the risk management of chemicals and nanomaterials. ERAs are based on the assumption that it is possible to provide accurate estimates of hazard and exposure and, subsequently, to quantify risk. In this paper we argue that since the quantification of risk is dominated by uncertainties, ERAs do not provide a transparent or an objective foundation for decision-making and they should therefore not be considered as a “holy grail” for informing risk management. We build this thesis on the analysis of two case studies (of nonylphenol and nanomaterials) as well as a historical analysis in which we address the scientific Foundation for ERAs. The analyses show that ERAs do not properly address all aspects of actual risk, such as the mixture effect and the environmentally realistic risk from nanomaterials. Uncertainties have been recognised for decades, and assessment factors are used to compensate for the lack of realism in ERAs. The assessment factors’ values were pragmatically determined, thus lowering the scientific accuracy of the ERAs. Furthermore, the default choice of standard assay for assessing a hazard might not always be the most biologically relevant, so we therefore argue that an ERA should be viewed as a pragmatic decision-making tool among several, and it should not have a special status for informing risk management. In relation to other relevant decision-making tools we discuss the use of chemical alternative assessments (CAAs) and the precautionary principle.

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Organisations: Department of Environmental Engineering, Environmental Chemistry, Roskilde University
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Ethical aspects of life cycle assessments of diets
Since the turn of the century a growing chorus of researchers has been espousing reduced meat and dairy intake as a partial strategy to transition towards a sustainable food system. Many of these studies have been predicated on a life-cycle assessment (LCA) methodology and though transparent in communicating their work within that framework, it has largely gone unmentioned that LCA involves a number of choices by the assessor and LCA methodology developers that are ultimately subjective. This study uses a consequential LCA of the average Danish diet in comparison to model vegetarian and vegan diets, leveraging the cultural perspectives afforded by the ReCiPe methodology, as starting point to explore the ways that subjectivity influences the LCA process and to test the robustness of the results against these different viewpoints. Mirroring earlier studies, we find vegetarian and vegan diets generally perform better environmentally compared to a standard Danish diet, but that there was minimal difference between the two no-meat options. Results were resilient to varying cultural perspectives applied in the model. LCA methodology, though loaded with value judgments, remains a dependable tool for assessing environmental dietary performance, but is less suited for estimating environmental pressures that are highly dependent on local conditions (e.g. chemical toxicity).

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Organisations: Department of Management Engineering, Quantitative Sustainability Assessment, Department of Environmental Engineering, Environmental Chemistry, University of Copenhagen
Contributors: Goldstein, B. P., Hansen, S. F., Gjerris, M., Laurent, A., Birkved, M.
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EU Regulation of Nanobiocides: Challenges in Implementing the Biocidal Product Regulation (BPR)

The Biocidal Products Regulation (BPR) contains several provisions for nanomaterials (NMs) and is the first regulation in the European Union to require specific testing and risk assessment for the NM form of a biocidal substance as a part of the information requirements. Ecotoxicological data are one of the pillars of the information requirements in the BPR, but there are currently no standard test guidelines for the ecotoxicity testing of NMs. The overall objective of this work was to investigate the implications of the introduction of nano-specific testing requirements in the BPR and to explore how these might be fulfilled in the case of copper oxide nanoparticles. While there is information and data available in the open literature that could be used to fulfill the BPR information requirements, most of the studies do not take the Organisation for Economic Co-operation and Development's nanospecific test guidelines into consideration. This makes it difficult for companies as well as regulators to fulfill the BPR information requirements for nanomaterials. In order to enable a nanospecific risk assessment, best practices need to be developed regarding stock suspension preparation and...
characterization, exposure suspensions preparation, and for conducting ecotoxicological test.

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How important is drinking water exposure for the risks of engineered nanoparticles to consumers?
This study explored the potential for engineered nanoparticles (ENPs) to contaminate the UK drinking water supplies and established the significance of the drinking water exposure route compared to other routes of human exposure. A review of the occurrence and quantities of ENPs in different product types on the UK market as well as release scenarios, their possible fate and behaviour in raw water and during drinking water treatment was performed. Based on the available data, all the ENPs which are likely to reach water sources were identified and categorized. Worst case concentrations of ENPs
in raw water and treated drinking water, using a simple exposure model, were estimated and then qualitatively compared to available estimates for human exposure through other routes. A range of metal, metal oxide and organic-based ENPs were identified that have the potential to contaminate drinking waters. Worst case predicted concentrations in drinking waters were in the low- to sub-µg/l range and more realistic estimates were tens of ng/l or less. For the majority of product types, human exposure via drinking water was predicted to be less important than exposure via other routes. The exceptions were some clothing materials, paints and coatings and cleaning products containing Ag, Al, TiO2, Fe2O3 ENPs and carbon-based materials.

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International Implications of Labeling Foods Containing Engineered Nanomaterials

To provide greater transparency and comprehensive information to consumers regarding their purchase choices, the European Parliament and the Council have mandated via Regulation 1169/2011 that foods containing engineered nanomaterials (ENMs) be labeled. This review covers the main concerns related to the use of ENMs in foods and the potential impacts that this type of food labeling might have on diverse stakeholder groups, including those outside the European Union (EU), e.g., in the United States. We also provide recommendations to stakeholders for overcoming existing challenges related to labeling foods containing ENMs. The revised EU food labeling requirements will likely result in a number of positive developments and a number of challenges for stakeholders in both EU and non-EU countries.

Although labeling of foods containing ENMs will likely improve transparency, provide more information to facilitate consumer decisions, and build trust among food safety authorities and consumers, critical obstacles to the successful implementation of these labeling requirements remain, including the need for (i) harmonized information requirements or regulations between countries in different regions of the world, (ii) clarification of the regulatory definitions of the ENMs to be used for food labeling, (iii) robust techniques to detect, measure, and characterize diverse ENMs in food matrices, and (iv) clarification of the list of ENMs that may be exempt from labeling requirements, such as several food additives used for decades. We recommend that food industries and food safety authorities be more proactive in communicating with the public and consumer groups regarding the potential benefits and risks of using ENMs in foods. Efforts should be made to improve harmonization of information requirements between countries to avoid potential international trade barriers.

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Organisations: Department of Environmental Engineering, Environmental Chemistry, RTI International
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BFI (2015): BFI-level 1
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Web of Science (2015): Impact factor 1.609
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BFI (2014): BFI-level 1
Meeting the Needs for Released Nanomaterials Required for Further Testing—The SUN Approach

The analysis of the potential risks of engineered nanomaterials (ENM) has so far been almost exclusively focused on the pristine, as-produced particles. However, when considering a life-cycle perspective, it is clear that ENM released from genuine products during manufacturing, use, and disposal is far more relevant. Research on the release of materials from nanoproducts is growing and the next necessary step is to investigate the behavior and effects of these released materials in the environment and on humans. Therefore, sufficient amounts of released materials need to be available for further testing. In addition, ENM-free reference materials are needed since many processes not only release ENM but also nanosized fragments from the ENM-containing matrix that may interfere with further tests. The SUN consortium (Project on "Sustainable Nanotechnologies", EU seventh Framework funding) uses methods to characterize and quantify nanomaterials released from composite samples that are exposed to environmental stressors. Here we describe an approach to provide materials in hundreds of gram quantities mimicking actual released materials from coatings and polymer nanocomposites by producing what is called "fragmented products" (FP). These FP can further be exposed to environmental conditions (e.g., humidity, light) to produce "weathered fragmented products" (WFP) or can be subjected to a further size fractionation to isolate "sieved fragmented products" (SFP) that are representative for inhalation studies. In this perspective we describe the approach, and the used methods to obtain released materials in amounts large enough to be suitable for further fate and (eco)toxicity testing. We present a case study (nanoparticulate organic pigment in polypropylene) to show exemplarily the procedures used to produce the FP. We present some characterization data of the FP and discuss critically the further potential and the usefulness of the approach we developed.

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Scopus rating (2008): SJR 2.96 SNIP 1.935
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Scopus rating (2007): SJR 2.774 SNIP 1.914
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.55 SNIP 1.893
Web of Science (2006): Indexed yes
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Web of Science (2005): Indexed yes
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Web of Science (2004): Indexed yes
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Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.392 SNIP 1.949
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Scopus rating (2001): SJR 2.387 SNIP 1.968
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Nanoproducts – what is actually available to European consumers?

It remains unclear which kinds of nanoproducts are available on the European market, although this information is a prerequisite for any kind of exposure and risk assessment. In order to address this lack of information, we have established The Nanodatabase (http://www.nanodb.dk), which is an online inventory of products claimed by manufacturers to contain nanomaterials (NMs) or be based on nanotechnology. The database currently entails 2231 products. The database is unique and includes basic information about the product (name, NM used, location of NM, product category, etc.) as well as a safety evaluation of each individual product according to the NanoRiskCat-framework. Our analysis of products that are currently present in the database shows that most products fall into “personal care” and “clothing” categories (≥300), followed by “sporting goods” and “cleaning” (>200). Silver and titanium dioxide are the most used NMs, but it is not possible to identify the NMs used for almost 60% of the products in the database. The data analysis shows that for most product categories the dominant route of exposure is dermal, and that the exposure potential as well as human and environmental hazard potential of most products is either “high” or “unknown”. In order to address the current lack of reporting by manufacturers when it comes to nanoproducts, we recommend that it is made mandatory to disclose and report any nanomaterials used in a consumer product and it becomes illegal to advertise and market products as “nano” when they have no content of nanomaterials.
Occupational Exposure Assessment of Nanomaterials using Control Banding Tools

Nanotechnology can be termed as the "new industrial revolution". A broad range of potential benefits in various applications for the environment and everyday life of humans can be related to the use of nanotechnology. Nanomaterials are used in a large variety of products already in the market, and because of their novel physical and chemical characteristics, the application of nanomaterials is projected to increase further. This will inevitably increase the production of nanomaterials with potential increase of exposure for the workers which are the first in line expected to become exposed to potentially hazardous nanomaterials.

Exposure assessment of nanomaterials is more difficult to define and conduct than that of traditional chemicals. This thesis provides an analysis of the field of occupational exposure assessment and a number of challenges are identified. The analysis showed that there are in general two approaches to assess the exposure of nanomaterials at the workplace: they can be measured or they can be estimated by modelling. It was pointed out that measurements are the standard approach used for the assessment of workplace exposure. However, as highlighted throughout the analysis, the assessment of conventional chemicals is well established with clear definition of which metric to use (generally mass concentration). For nanoparticles the assessment procedures are not defined yet and there is debate on which metric should be used (e.g., mass, surface, size-number distribution).

Similarly to measurements, it was found that models in general can be used successfully and effectively in assessing the exposure to conventional chemicals. Several models are suggested also by the European Chemicals Agency (ECHA) in the technical guidance document R.14 for the assessment of occupational exposure and some of them are under a validation process. However, difficulties arise when the existing models for chemicals are applied to nanoparticles, because of the rapid changes of the nanoparticles in aerosols, which is mainly due to different processes of transformation (agglomeration and aggregation, deposition, chemical reactions, and potential mixing and interaction between the nanomaterial and the background aerosol). Moreover, there are no extensive historical data for comparison and model calibration.

Nevertheless, as it is illustrated throughout this thesis, application of modelling for occupational exposure assessment to nanomaterials is still a promising route.

A few years ago a new conceptual model for the assessment of inhalation exposure to nanomaterials was developed. As illustrated in this thesis, this new model includes considerations on nanoparticles behaviour and physical and chemical properties. In addition, several Control Banding (CB) tools for estimating the exposure to nanomaterials have been developed. An evaluation of current CB tools showed that they are all meant for a qualitative or semi-quantitative exposure assessment of nanomaterials. Two of these tools, NanoSafer and Stoffenmanager Nano, are relatively advanced, and they are good foundations for an advanced exposure assessment. Considering the tiered approach for workplace assessment proposed by the OECD, these two tools could be situated, between Tier 1 (Information gathering) and Tier 2 (Basic exposure assessment).

Moreover, the thesis and the included scientific papers provide an in-depth analysis and a case study of CB tools. A set of parameters were identified which should always be taken into account for occupational assessment of inhalation exposure.
to nanoparticles. Harmonization considering a set of parameters was encouraged in order to pursue the development of an advanced CB tool for occupational exposure assessment to nanomaterials. Such a model could be a suitable strategic component for a first exposure assessment and may also improve the risk communication between stakeholders involved in risk assessment of nanomaterials at the workplace.

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Quantification of dermal exposure to nanoparticles from solid nanocomposites by using single particle ICP-MS
Engineered nanoparticles are used in various applications due to their unique properties, which has led to their widespread use in consumer products. Silver, titanium and copper-based nanoparticles are few of the most commonly used nanomaterials in consumer products, mainly due to their biocidal, optical or photocatalytical properties. There is a lot of research focusing on effects exerted by nanoparticles, but the knowledge concerning release and subsequential exposure to nanoparticles is very limited, and information regarding potential dermal exposure from nanomaterial
containing solid articles in particular is currently lacking. Challenges with regard to qualitative and quantitative characterization of nanoparticle exposure have been increasingly addressed in the literature in the last decade, and single particle ICP-MS has shown to be one of the most promising techniques for nanoparticle detection and characterization. In this study, we have investigated the potential dermal exposure to three different types of nano-enabled consumer products: Ag-containing keyboard covers, TiO2 coated ceramic tiles, and wood painted with CuO containing paint. The potential for dermal transfer from the aforementioned surfaces was tested by surface wiping followed by analysis using single particle ICP-MS. The nanoparticles were extracted from the wipes by ultrasonication in deionized water, and this technique was validated to be around 60-100% effective for extracting the particles adsorbed to the wipes. The method was optimized by spiking the wipes with known amounts of nanoparticles and treating them the same way as the experimental samples. Our preliminary results show that single particle ICP-MS has the potential for quantitatively measuring potential dermal exposure to nanoparticles, and when used in combination with other characterization techniques, such as conventional ICP-MS (for analysis of total metal content) and electron microscopy (particle shape) it can provide necessary particle characterization that can aid consumer exposure assessment to nanoparticles.

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Contributors: Mackevica, A., Olsson, M. E., Hansen, S. F.
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Release of nanomaterials from consumer products and implications for consumer exposure assessment
During the past decade the number of consumer products that contain nanomaterials (NMs) has increased rapidly. Materials manufactured at the nanoscale exhibit unique physiochemical properties and have greater reactivity in comparison to the bulk material. Because of this, NMs are being utilized in a wide variety of products, ranging from food and personal care products to electronics and large appliances.

Over the course of the last four years, the number of products claiming to contain NMs has increased from 1 200 in 2012 to more than 2 300 in 2016. The increasing use of nanoproducts and the uncertainties associated with the risks they may pose is raising concerns about consumer safety. During the use of nano-enabled products there is a potential for NM release, which can consequently lead to consumer and/or environmental exposure. Consumer exposure testing has only recently started to receive some attention, and the data currently available in the literature is scarce. Most studies are addressing only a narrow range of product categories and a few NM types, having experimental setups that are rarely comparable from study to study. Moreover, the analytical techniques applied for release testing are rarely suitable for reporting NM release with particle number concentration, size distribution or surface area concentration, which are known to be of toxicological importance.

The work presented in this thesis addresses the lack of data on consumer exposure to NMs from various consumer products. First, data from literature and online databases was used to obtain an overview of what nanoproducts are available on the EU market, and which nanoproducts have been experimentally tested for their potential NM release. Specific focus was placed on evaluating suitable analytical methods for NM quantification and characterization. The findings showed that single particle inductively coupled plasma mass spectrometry (spICP-MS) in combination with other methods is a well suited analytical technique that can provide extensive NM characterization, such as mass and number concentration, and size distribution of NMs. Then, several nano-enabled products were selected for experimental testing of NM release, namely four types of food contact materials (Ag) and two types of toothbrushes (Ag) for potential oral exposure, as well as five types of textiles (TiO2) and five different surface coatings (Ag and CuO) for potential dermal exposure. The NM release was characterized by using spICP-MS and transmission electron microscopy (TEM), together providing data for NM mass and number concentration, size distribution, and morphology. In most cases, it was found that NM release from the consumer products was in the ng/g (or ng/cm2 where applicable) range. Ag release from food contact materials and toothbrushes was tested in food simulators (deionized DI water, ethanol, acetic acid) and tap water, respectively. The results showed that there is a potential for Ag exposure both in dissolved and nano-particulate form (up to around 6 µg/L and 40 000 particles/mL), but the amounts were magnitudes below the permitted Ag exposure limits set by European Food Safety Authority (EFSA) and World Health Organization (WHO). The TiO2 release was tested for five types of textiles that did not openly disclose TiO2 content. The fabrics were immersed in DI water, and the resulting amounts of potential Ti exposure were found to be up to around 8 000 particles/cm2 corresponding to around 24 ng/cm2. These amounts may be considered negligible compared to the reported Ti amounts in a wide range of products available on the market that claim to contain nano-TiO2 as an additive, especially when it comes to food products. Dermal exposure testing for Ag and CuO surface coatings was done by wiping tests and revealed particle release very close to background levels, unless the surface was subjected to abrasion before executing the wiping tests. In general, all the products that were tested released very low amounts of the initial NM content present in the product, indicating that throughout long-
term use of the products there might be continuous NM release, or most of the NMs would end up in solid waste. The NM release data obtained both from the literature and from the experimental studies presented in this thesis were subsequently used for consumer exposure estimation. Several consumer exposure assessment tools were identified and their applicability for NM exposure assessment is discussed in this thesis. It was concluded that current consumer exposure assessment models have not been designed for estimating NM-relevant exposures, as they are mainly dealing with mass as a dose metric, without taking NM properties into consideration. This highlights the need of developing tools that are specifically designed for NM exposure assessment, taking into account not only potential exposure in terms of total NM mass, but also number concentration and size distribution.

All in all, the work presented in this thesis underlined various important issues that need to be considered and addressed when completing nanoproduct release testing, NM quantification and characterization, data reporting, and consumer exposure assessment. Firstly, there is an urgent need to apply a combination of characterization methods to gain a better understanding about the potential NM exposure. Secondly, standardization of NM release testing and data reporting is of key relevance, to ensure that the data generated is comparable among studies and can be extrapolated to other nanoproducts with similar properties. Finally, standardized data reporting and exposure assessment is of utmost importance to move towards harmonization of NM exposure and hazard characterization that could further aid NM-relevant risk assessment.
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Web of Science (2018): Indexed yes
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Web of Science (2016): Impact factor 6.428
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 7.14
Web of Science (2015): Impact factor 7.913
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.92
Web of Science (2014): Impact factor 6.411
Web of Science (2014): Indexed yes
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BFI (2012): BFI-level 2
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Semi-quantitative analysis of solid waste flows from nano-enabled consumer products in Europe, Denmark and the United Kingdom - Abundance, distribution and management

Many nano-enabled consumer products are known to be in the global market. At the same time, little is known about the quantity, type, location etc. of the engineered nanomaterials (ENMs) inside the products. This limits the scientific investigations of potential environmental effects of these materials, and especially the knowledge of ENM behaviour and potential effects at the end-of-life stage of the products is scarce. To gain a better understanding of the end-of-life waste treatment of nano-enabled consumer product, we provide an overview of the ENMs flowing into and throughout waste systems in Europe, Denmark and the United Kingdom. Using a nanopoduct inventory (nanodb.dk), we performed a four-step analysis to estimate the most abundant ENMs and in which waste fractions they are present. We found that in terms of number of products: (i) nano silver is the most used ENM in consumer products, and (ii) plastic from used product containers is the largest waste fraction also comprising a large variety of ENMs, though possibly in very small masses. Also, we showed that the local waste management system can influence the distribution of ENMs. It is recommended that future research focus on recycling and landfilling of nano-enabled products since these compartments represent hot spots for end-of-life nanoproducts.
Silver nanoparticle release from commercially available plastic food containers into food simulants

Silver nanoparticles (AgNPs) are currently being used in many different kinds of consumer products in order to take advantage of their antimicrobial properties. However, the potential migration of silver nanoparticles into food and subsequent consumer exposure has hardly been addressed. In the current study, we investigated four brands of commercially available plastic food storage containers and measured the total amount of silver, particle size and number concentration, and the migration rates into three different food simulants (Milli-Q grade water, 10 % ethanol, and 3 % acetic acid) for 10 days at 40 °C. The experimental setup was made according to the European Commission Directive (EU
The total amount of silver in plastic containers and migration solutions was quantified by ICP-MS analysis, and the size of the migrated particles was investigated by single particle ICP-MS and TEM-EDS. The total mass and median size of released particulate Ag were generally highest in 3 % acetic acid for three out of four food container brands. The total content of silver in the containers varied from 13 to 42 µg/g. The highest migration was observed in the 3 % acetic acid food simulant for all four brands of containers, with total silver release up to 3.1 ng/cm² after 10 days. In conclusion, the experimental results show that silver has the potential of migrating into food, especially when in contact with more acidic substances.

**General information**

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Scopus rating (2017): CiteScore 1.93 SJR 0.528 SNIP 0.603
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Scopus rating (2016): CiteScore 1.74 SJR 0.496 SNIP 0.557
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Scopus rating (2015): CiteScore 1.97 SJR 0.568 SNIP 0.696
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Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.17 SJR 0.672 SNIP 0.861
Web of Science (2014): Impact factor 2.184
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.56 SJR 0.855 SNIP 1.024
Web of Science (2012): Impact factor 2.175
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 3.52 SJR 1.092 SNIP 1.437
Web of Science (2011): Impact factor 3.287
ISI indexed (2011): ISI indexed yes
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Support for 3rd regulatory review on nanomaterials – environmental legislation: Project Report

Ricardo Energy & Environment, in partnership with subcontractors Milieu Consulting and the Technical University of Denmark (DTU), was commissioned by the European Commission to carry out a project entitled “The preparation of the third regulatory review on nanomaterials - environmental legislation”, specific contract number 070201/ENV/2015/SI2.716613/ENV.A3, Commission reference ENV.C.3/ETU/2015/0030. The study objective was to compile and develop information on nanomaterials and advanced materials in the environment and explore further the regulatory implementation challenges. The study had three main components: - A preliminary evaluation of releases of nanomaterials to different media (air, water, land, recycling and waste disposal). - A review of progress on the application of environmental and other key legislation to nanomaterials. - A prospective view on future developments in advanced materials, and challenges for environmental legislation. Consultation with stakeholders was carried out by email and telephone, and a stakeholder workshop was held on 21 June 2016. At the workshop, the interim findings were presented, and stakeholder feedback and views were discussed. Following the workshop, stakeholders provided feedback in writing. This feedback has been taken into account for the finalisation of the report.

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Comparing Titanium Release from Ceramic Tiles using a waste material characterization test - Influence of Calcium and Organic Matter concentrations

Nanomaterials are beneficial in the building industry to enhance or add certain features to commonly used materials. One example is the use of nano-titanium dioxide in the surface coating of ceramic tiles, to make the tiles surface self-cleaning. At the end of life stage, ceramic tiles might be deposited in landfills for construction and demolition waste or other types of landfills, depending on the local waste management system. Hence, the potential release of nano-Ti under landfill conditions is relevant to investigate. In this study we used a standard waste material characterization method to assess if nano-titanium dioxide coated ceramic tiles are suitable for depositing in a landfill or not. Specifically, we used compliance batch test method, which is a simple test evaluating the release from a solid material to an aqueous media during 24 hrs. If nano-Ti particles are released from solid waste material to the landfill leachate, it is expected that the calcium and organic matter content in the liquid will affect the stability of the nanoparticles. The concentration of calcium in the landfill percolate is expected to decrease the stability of the particles due to compression of the electric double layer surrounding the particle, causing increased particle agglomeration and settling. Natural organic matter might have both a stabilizing and destabilizing effect on the released nano-Ti particles depending on the concentration, since this will specifically influence the ability of the organic matter to fully cover the surface of the particles. We evaluated the titanium release from identical ceramic tiles - with and without a nano-titanium dioxide coating - and varied the concentrations of calcium chloride (100-500 mg/l) and humic acid (25-100 mg/l). The titanium release was quantified immediately after the 24 hrs. test using single particle ICPMS and Transmission Electron Microscopy imaging. The preliminary results suggest that nanoparticulate titanium is released from both tiles – with and without nano-titanium dioxide coating. The size distributions of the released particles are similar and show a high polydispersity. Further, the median size of the particles is generally above 100nm. However, the results suggest some effect of the humic acid on the particle size distribution, which needs to be investigated further. These results can aid the further development of models for environmental concentrations of nanomaterials, specifically concerning the life cycle of nano-enabled products.

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Current state of knowledge when it comes to consumer exposure to nanomaterial embedded in a solid matrix

Little is known about consumer exposure to engineered nanomaterials (ENMs) stemming from NM-containing consumer products. Here, we focus especially on studies that have investigated the release of ENMs from consumer products, investigating to what extent the information in the open literature can be used to fulfill the requirements outlined in the European chemical legislation, REACH. In total, we have identified about 75 publications of relevance and the number of publications is increasing every year. The most studied materials include silver and titanium dioxide NPs, CNTs and SiO2. If reported, we summarized the studies by identifying nanomaterial(s), product name, product type, Product or Article Category according to REACH; experimental setup, total content in product, information on release, techniques used for characterization of nanomaterials both in product matrix and in the released form. For studies that report enough information, we developed potential exposure scenarios and derived exposure estimates according to REACH R.16 using the Tier 1 equations for consumer exposure estimation and Tier 1 tools i.e. ECETOX TRA and Consexpo. In general, we find that the information and data provided by each of the studies rarely contain all the information entries that one would need to complete exposure assessments according to REACH.

DPSIR and Stakeholder Analysis of the Use of Nanosilver

First concerns about the use of nanosilver were raised almost a decade ago, but assessing the risks has been extremely challenging scientifically, and regulation to protect environmental and human health remains controversial. In order to understand the known risks and issues associated with the use of nanosilver, we carried out a DPSIR analysis and analysed drivers, pressures, state, impacts and potential policy responses. We found that most concerns relate to the potential development of multi-resistant bacteria and the environmental impacts of nanosilver. From the DPSIR analysis, we found that new (separate) legislation for nanomaterials in general and nanosilver-specific changes in the current European chemical, biocide and medical legislation were the optimal policy responses, along with limiting the overall use of nanosilver. In order to qualify the identified potential policy responses, we carried out a stakeholder analysis, in order to explore possibilities for reaching consensus amongst stakeholders. Through the stakeholder analysis, the interests, views, power and influence of the identified stakeholders were mapped. Overall, the policy options identified in the DPSIR analysis were deemed not to be implementable, as industry and NGOs seem to have fundamentally conflicting views and interests. The use of the combination of DPSIR and stakeholder analysis proved valuable for use in cases of complexity, as they compensate for each other's limitations and open up for a discussion what can be done to reduce risks.
Environmentally sustainable nanoparticles - Towards a new paradigm for ecotoxicity testing and hazard assessment of engineered nanoparticles

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Microplastics: Occurrence, effects and sources of releases to the environment in Denmark

This report contains a review of existing knowledge on issues related to contamination by micro-plastic with a focus on the use and release of micro-plastics in Denmark and the occurrence of micro-plastics in the surrounding waters.

Micro-plastic defined as small plastic pieces of 1µm to 5 mm.

Micro Plastics are detected in organisms at all levels of the marine food chain as well as in water and sediment.

There are potentially three types of adverse effects of the micro-plastic: (1) physical effects related to the intake, (2) toxic response by the release of hazardous substances in the plastic and, (3) toxic reaction to the pollutants which are adsorbed to micro plastic. These effects are shown in laboratory experiments but not proven to occur in the environment.

Although the majority of the micro plastics in the waste water end up in the sewage sludge, wastewater treatment plants are important potential sources of emission of the micro-plastics in the ocean.

The most important sources of release of micro-plastics to the environment are tires, paints, road markings, textiles, etc. The report estimates that only minor significance to micro plastic used directly in certain products (for example, in cosmetics or for use in blowing agents).
Nanodatabase (www.nanodb.dk), an online inventory of products claimed by manufacturers, importers, retailers, and web-shops to contain nanomaterials. The database currently entails almost 1400 products, 200 of which in the categories of cleaning and personal care. While including basic information about the product (e.g., name, NM used, location of NM in the product), a unique feature of the database is that it provides qualitative exposure/hazard evaluation of individual products based on the NanoRiskCat evaluation framework. Furthermore, the analysis section of the Nanodatabase website allows the user to do their own data sorting (product types, NMs used, number of products, etc.). While silver and titanium dioxide are the most used NMs, we could not identify the NM in more than 60% of all products. The presentation will furthermore include data on potential route of exposure to humans and the environment, results of the NanoRiskCat evaluation, distribution of the products according to their end-of-life fate and limitations of the database.

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New rooms for blended learning

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Potential exposure and treatment efficiency of nanoparticles in water supplies based on wastewater reclamation
Water scarcity brings an increased focus on wastewater reclamation for drinking water supply. Meanwhile, the production volume of nanoparticles (NPs) is rapidly increasing, but to date there has been little attention given to the fate of NPs in water systems based on wastewater reclamation. We have investigated the possible concentrations of silver (Ag), titanium dioxide (TiO2), and zinc oxide (ZnO) nanoparticles in tap water for water supplies based on reclaimed wastewater. Tap water concentrations of the NPs were assessed by mass flow analyses of two typical wastewater reclamation concepts: 1) advanced membrane treatment and 2) bank infiltration, similar to systems established in Orange County, CA, USA and Berlin, Germany. The mass flow analyses are based on a literature review of known wastewater concentrations of NPs and removal efficiencies for the implemented treatment stages in two case systems. Few studies are available on the removal efficiencies of NPs by advanced water treatment processes with a majority of the identified studies focusing on removal efficiencies in wastewater treatment plants and fate in surface waters. The NP removal efficiency of several treatment processes is unknown at this stage. We found the worst case removal efficiencies for the two cases to be 97–99.97% for Ag-NPs, 91–99.2% for TiO2-NPs, and 92–93% for ZnO-NPs. The corresponding worst case concentrations in tap water for the advanced membrane treatment were 0.04 μg L−1 (Ag), 147 μg L−1 (TiO2), and 0.28 μg L−1 (ZnO). The concentration of ZnO-NPs also includes zinc ions, thus the concentration of ZnO-NPs is likely to be lower than that indicated here. The worst case removal by the wastewater reclamation bank infiltration system was predicted to lead to tap water concentrations of up to 3.3 μg L−1 (Ag), 13 μg L−1 (TiO2), and 0.25 μg L−1 (ZnO). Overall, it is found that the primary removal mechanisms of NPs are aggregation, sedimentation, coagulation, and biosorption; this supports observations that conventional biological treatment processes are likely to be effective barriers against NPs. Advanced treatment methods such as microfiltration and ultrafiltration can exhibit very low removal of ZnO-NPs or zinc ions due to dissolution of ZnO-NPs. There are marked knowledge gaps, and further research on NP fate in water treatment is encouraged.
Potential Nanomaterial Enhanced Conflicts

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Potential Nanomaterial Enhanced Conflicts

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The Applicability of Chemical Alternatives Assessment for Engineered Nanomaterials

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The challenges of ecotox testing of nanomaterials and the BPR
The European Biocidal Product Regulation (BPR) requires dedicated risk assessment of nanomaterials. When it comes to ecotoxicological testing of nanomaterials, meeting these requirements is especially challenging. Overall, these challenges fall into four overall categories: 1) materials characterization, 2) exposure preparation, 3) monitoring stability and 4) monitoring time. In this paper, the challenges are presented and discussed. There is no easy manner in which to deal with the challenges related to ecotoxicological testing of nanomaterials in the light of the BPR requirements. It short the current answer seems to be describe, characterize and document. Characterization is vitally important and has to be done using multiple methods on the nanomaterials as received, in the test media with and without the organisms.

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Transformation and distribution processes governing the fate and behaviour of nanomaterials in the environment: an overview

Analytical methods are currently challenged when it comes to detecting and quantifying nanomaterials in the environment. This leaves a gap between the present scientific state-of-the-art and the increasing demand for reliable measured or predicted environmental concentrations for environmental risk assessment. Chemical fate modelling is one approach to fill this gap within a short time frame. To ensure the reliability of predicted environmental concentrations informed choices are needed during model formulation and development. A major knowledge gap, hampering the further development of such model-based approaches, relates to the interplay between the nanomaterial physico-chemical properties, surrounding media/matrix composition and the underlying processes that determine particle behaviour. Here we identify and summarize key processes governing the fate and behaviour of nanomaterials in the environment. This is done through a critical review of the present state-of-knowledge. We describe the (photo)chemical, physical or biologically mediated transformation of manufactured nanomaterials due to degradation, aggregation, agglomeration, or through association with dissolved, colloidal or particulate matter present in the environment. Specific nanomaterials are used as case studies to illustrate these processes. Key environmental processes are identified and ranked and key knowledge gaps are identified, feeding into the longer-term goal of improving the existing models for predicted environmental concentrations.

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Waste management of ENM-containing solid waste in Europe
Little research has been done to determine emissions of engineered nanomaterials (ENM) from currently available nano-enabled consumer products. While ENM release is expected to occur throughout the life cycle of the products, this study focuses on the product end-of-life (EOL) phase. We used the Danish nanoproduct inventory (www.nanodb.dk) to get a general understanding of the fate of ENM during waste management in the European context. This was done by: 1. assigning individual products to an appropriate waste material fraction, 2. identifying the ENM in each fraction, 3. comparing identified waste fractions with waste treatment statistics for Europe, and 4. illustrating the general distribution of ENM into incineration, recycling and landfilling. Our results indicate that plastic from used product containers is the most abundant and diverse waste fraction, comprising a variety of both nanoproducts and materials. While differences are seen between individual EU countries/regions according to the local waste management system, results show that all waste treatment options are significantly involved in nanowaste handling, suggesting that research activities should cover different areas. The results of this study may be used for the environmental and human health risk assessment of nanowaste, and to assist future regulatory and management decisions.

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The EU needs more anticipatory funding of health and environmental research
In recent months, there have been several attacks on the Precautionary Principle and how the principle has been used in the EU. For example, the scientific advisor to the President of the European Commission, Ann Glover, has accused Commissioners of having “crazy ideas” about the safety of nanotechnologies, genetically modified organisms, shale gas, endocrine disrupters, etc. (See EU twisting facts to fit political agenda, chief scientist says and EU science advisor: ‘Lots of
policies are not based on evidence’). Similarly, it has been argued that policymakers often misuse the precautionary principle.

Adequate and anticipatory research on the potential hazards of emerging technologies: a case of myopia and inertia?

History confirms that while technological innovations can bring many benefits, they can also cause much human suffering, environmental degradation and economic costs. But are we repeating history with new and emerging chemical and technological products? In preparation for volume 2 of ‘Late Lessons from Early Warnings’ (European Environment Agency, 2013), two analyses were carried out to help answer this question. A bibliometric analysis of research articles in 78 environmental, health and safety (EHS) journals revealed that most focused on well-known rather than on newly emerging chemicals. We suggest that this ‘scientific inertia’ is due to the scientific requirement for high levels of proof via well replicated studies; the need to publish quickly; the use of existing intellectual and technological resources; and the conservative approach of many reviewers and research funders. The second analysis found that since 1996 the funding of EHS research represented just 0.6% of the overall funding of research and technological development (RTD). Compared with RTD funding, EHS research funding for information and communication technologies, nanotechnology and biotechnology was 0.09%, 2.3% and 4% of total research, respectively. The low EHS research ratio seems to be an unintended consequence of disparate funding decisions; technological optimism; a priori assertions of safety; collective hubris; and myopia. In light of the history of past technological risks, where EHS research was too little and too late, we suggest that it would be prudent to devote some 5–15% of RTD on EHS research to anticipate and minimise potential hazards while maximising the commercial longevity of emerging technologies.
Balancing scientific tensions

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Contributors: Wickson, F., Hartmann, N. I. B., Hjorth, R., Hansen, S. F., Wynne, B., Baun, A.
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Environmental exposure assessment framework for nanoparticles in solid waste

Information related to the potential environmental exposure of engineered nanomaterials (ENMs) in the solid waste management phase is extremely scarce. In this paper, we define nanowaste as separately collected or collectable waste materials which are or contain ENMs, and we present a five-step framework for the systematic assessment of ENM exposure during nanowaste management. The framework includes deriving EOL nanoproducts and evaluating the physicochemical properties of the nanostructure, matrix properties and nanowaste treatment processes as well as transformation processes and environment releases, eventually leading to a final assessment of potential ENM exposure. The proposed framework was applied to three selected nanoproducts: nanosilver polyester textile, nanoTiO2 sunscreen lotion and carbon nanotube tennis racquets. We found that the potential global environmental exposure of ENMs associated with these three products was an estimated 0.5–143 Mg/year, which can also be characterised qualitatively as medium, medium, low, respectively. Specific challenges remain and should be subject to further research: (1) analytical techniques for the characterisation of nanowaste and its transformation during waste treatment processes, (2) mechanisms for the release of ENMs, (3) the quantification of nanowaste amounts at the regional scale, (4) a definition of acceptable limit values for exposure to ENMs from nanowaste and (5) the reporting of nanowaste generation data.
Environmental fate and behaviour of nanomaterials: New knowledge on important transformation processes

In the current report, the existing knowledge on the fate of nanomaterials in the environment is reviewed and the major knowledge gaps are identified.
Horizon-Scanning and Identification of Emerging Risks among Nanotech Companies in Denmark

In order to understand how companies identify and handle emerging risks related to nanomaterials, we completed more than 15 in-depth interviews with key personnel in various Danish companies. Companies varied greatly in regard to number of employees and overall R & D capacity and health and safety personnel, but also in regard to level of which, they already used/produce products that contain nanomaterials. Surprisingly, very little research has been done on: 1) How companies identify emerging risks, 2) Collect and analyze data on these risks, 3) how they communication results of their analysis internally and externally, 4) how they complete their analysis of management options and subsequently implementation of these management options and finally, 5) what the implications of action taken has been.

Blue-color employees noting “that something might not be right” as well as the media rumors turned out to be the two main sources of identification of emerging risks, whereas ad hoc personal and non-formal networks and meetings with academics and health care officials also played a role. In most cases, various sources were used in obtain more factual information including: Google; Newsletters from the National Research Centre for the Working Environment; chemistry databases and scientific articles, but the information gathering process itself was somewhat unsystematic and seems to be completed ad hoc over time. Internal data analysis was performed by occupational health personal within the companies in constant consideration of resources available, priorities, possible management options, etc. unless health personal “felt like it” putting far more effort into it. Very often independent external experts were consulted in order to learn more and get outside confirmation of key internal findings and interpretations of the available literature.

The selection of management options often involved a pro et con analysis of various options considering various technical and operational barriers whereas implementations often followed a process of: 1) Double-checking that company is in compliance with existing legislation and guidelines - often non-NM specific; 2) Initial mapping of NM R & D within the company; 3) Initiation of a capacity building process; 4) Mapping of NM exposure (sometimes very extensive); 5) Mapping of health effects among employees (again sometimes very extensive) and 6) Mapping and implementation of possible management options. Overall, very few options had been implemented about mostly “easy”, “low-hanging fruit” - PE-options and administrative controls. Results were mostly communicated internally via intranets or internal workshops with health representatives.

Externally communications included publication of scientific papers, posting of information on company websites, but surprisingly involve no or very limited dialogue with authorities as this was considered irrelevant at best and potentially a source of additional confusion and bureaucracy. Overall, implications of action taken within the companies have had little impacts, but in generally company representatives noted that they had gotten an improved knowledge about NM risks; that there was a general alertness regarding risks related to airborne NPs and – in some companies - that there was an increased dialogue between workers and leadership.
Late Lessons from Early Warnings: Is it impossible to learn from history?

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Leaching potential of nanomaterials during different human contact scenarios and end-of-life

In order to understand how much, when and by which mechanisms nanomaterials are released during the life cycle of a given application, we have experimentally investigated the release of nanoparticles (NP) from a wide range of products. These include silver and titanium dioxide NP released from food storage containers, titanium dioxide released from coated ceramic tiles, iron (III) oxide NP from polyethylene granulates and silver NP released from toothbrushes. In our investigation, we focused specifically on release during the consumer use phase and the waste handling phase as these two aspects of the life cycle seem to be especially important and not well understood. In order to get an estimation of the overall release potential of nanomaterials during the consumer use phase and the waste phase, we also mapped consumer products on the EU market claiming to be nano-enabled and commercially available online (see www.nanodb.dk) as well as the waste flows of these consumer products. We identified more than 1275 products to be available in the EU. Almost 200 products of these are claimed to contain nanosilver, but for more than 800 products the identity of the nanomaterial used was not reported. Based on information available online, the consumer products were categorized into waste material fractions, and we found that "Dirty plastic" (e.g. used bottles and containers) was clearly the dominating waste fraction for nano-enabled products. CNTs and other nanomaterials were primarily represented in one or two waste fractions, whereas nanosilver was found to be present in six of the eight identified waste fractions.

Mapping ENM from consumer products in solid waste flows in Denmark

To address the challenges regarding management of waste from ENM-enabled consumer products, we mapped the flow of these products available online in Denmark and the EU. To do this, we used the Nanodatabase (www.nanodb.dk). A representative sample of products from the database was analyzed, and placed into suitable waste material fractions. Subsequently, the distribution of ENM in the individual waste fractions, by number of products, was found. Overall, the results showed that nanosilver was present in seven of the eight identified waste material fractions, whereas other ENMs (e.g. CNTs and silicon) were only present in one or two fractions. Furthermore, the waste material fraction "dirty plastic" was the most diversified, containing five different ENMs. To our knowledge this type of analysis has not previously been performed, and the results hold promise for gaining a better understanding of managing nanowaste.
NanoRiskCat: a conceptual tool for categorization and communication of exposure potentials and hazards of nanomaterials in consumer products

The literature on nano(eco)toxicology is growing rapidly and has become increasingly difficult to interpret. We have developed a systematic tool called NanoRiskCat that can support companies and regulators in their first-tier assessment and communication on what they know about the hazard and exposure potential of consumer products containing engineered nanomaterials. The final outcome of NanoRiskCat is communicated in the form of a short-title describing the intended use and five colored dots. The first three dots refer to the qualitative exposure potential for professional end-users, consumers and the environment, whereas the last two refers to the hazard potential for humans and the environment. Each dot can be assigned one of four different colors, i.e. red, yellow, green, and gray indicating high, medium, low, and unknown, respectively. In this paper, we first introduce the criteria used to evaluate the exposure potential and the human and environmental hazards of specific uses of the nanoproduct. We then apply NanoRiskCat to eight different nanoproducts. The human and environmental exposure potential was found to be high (i.e., red) for many of the products due to direct application on skin and subsequent environmental release. In the NanoRiskCat evaluation, many of the nanomaterials achieve a red human and environmental hazard profile as there is compelling in vivo evidence to associate them with irreversible effects, e.g., carcinogenicity, respiratory, and cardiovascular effects, etc., in laboratory animals. A significant strength of NanoRiskCat is that it can be used even in cases where lack of data is prominent.
NanoRiskCat and nanodb.dk – Advancing Sustainability through Safety and Risk Evaluation of Nanomaterials and Products in Europe

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PNEC – Predicted No Effect Concentration: PNEC – Potential Nanomaterial Enhanced Conflicts

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Potential Nanomaterial Enhanced Conflicts

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(Annual Meeting, Vol. 35).
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This report provides a summary of discussion at the European Environment Agency's Scientific Committee Seminar on 12 February 2014 in Copenhagen.

General information
Sustainable nanomaterials? – How to apply "early warning signs" to screen nanomaterials for harmful properties

In 2001 the European Environment Agency (EEA) published a report that analyzed 14 cases of technological developments that later on turned out to have negative side-effects and they identified 12 “late lessons” for current and future policy-makers to bear in mind when initiating new technological endeavors. This presentation explores how the first lesson – “Acknowledge and respond to ignorance, uncertainty and risk in technology appraisal” could be applied to screen nanomaterials. In cases of ignorance, uncertainty and risk, the EEA recommends paying particular attention to important warning signs such as novelty, persistency, whether materials are readily dispersed in the environment, and whether they bioaccumulate or lead to potentially irreversible action. Through an analysis of these criteria using five well-known nanomaterials (titanium dioxide, carbon nanotubes, liposomes, poly(lactic-co-glycolic acid) and nanoscale zero-valent iron), it was found that only nanoTiO2 fulfills all the five criteria. Depending on the length of the nanotubes, carbon nanotubes fulfill 3 or 4 criteria whereas liposomes, poly(lactic-co-glycolic acid), nanoscale zero-valent iron fulfill only one criteria. We will discuss how these warning signs can be used by different stakeholders such as nanomaterial researchers and developers, companies and regulators to design benign nanomaterials, communicate what is known about nano-risks and
decide on whether to implement precautionary regulatory measures.

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**The biocides market for nano actives**
Information is emerging on which nanomaterials might be used in biocides, but new test methods are needed.

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**The downsides of innovations: anticipate and act rather than ignore?**
Martin Krasnik's battle against stupid and hypocritical morons.

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**Transformation and distribution processes governing the fate and behaviour of nanomaterials in the environment: an overview**

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Comparison of occupational exposure assessment tools and concepts for nanomaterials

The development, production and application of engineered nanomaterials have been growing in different fields. This leads to a consequent increased potential of exposure to nanomaterials in the working environment. However to determine the potential exposure risk is a challenging task for risk assessors, due to limited availability of data on nanomaterial exposure level. To face this challenge a number of methods have been developed including the "Control Banding Nanotool", the "Swiss precautionary matrix"; "Stoffenmanager Nano version 1.0; “ANSES - Development of a specific Control Banding Tool for Nanomaterials”; “NanoSafer vs. 1.1 – A web-based precautionary risk assessment tool for manufactured nanomaterials using first order modeling”

Based on the literature information we have analyzed these tools and discussed elements regarding: the domain of application and whether it accounts for the nanospecific factor or nano-relevance; the work exposure scenario, for which types of processes they may be used; are the tools using the source-transmission-receptor approach; the input data requirements; whether the tools included qualitative or semi-quantitative or quantitative evaluations of the exposure; whether the final output is qualitative or semi-quantitative or quantitative.

We observed that the tools were developed based on different needs, but that the domain of application is not always well defined. Moreover, derived exposure potentials or exposure levels are usually based on assumptions or expert opinions, and some concepts were purely theoretical. Therefore, immediate combination of the different models into a larger holistic framework is not possible. Further development of the frameworks, harmonization and validation is needed in future research.

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Comparison of occupational exposure assessment tools and concepts for nanomaterials

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Environmental and Ethical Aspects of Sustainable Mining in Greenland

The increased use of scarce metals in combination with climate changes pave way for extensive extraction of mineral resources in Greenland. The focus of this study is on environmental ethical aspects of mining activities in a vulnerable and unspoiled arctic nature. Mining can have several economic and social benefits for Greenland. On the other hand, the environmental impacts from mining are well known. Through DPSIR (Drivers, Pressures, States, Impacts, Responses) and Stakeholder analysis, we assess how future mining in Greenland can be sustainably implemented. The analysis revealed that numerous stakeholders have to be taken into consideration with a wide range of different interests. The DPSIR analysis clarified the availability of various potential political responses that could affect the drivers, pressures, states and impacts of mining mainly focused on implementation of effective environmental regulation strategies. Our findings revealed different environmental ethical dilemmas of which the most critical is how Greenland can open up for mining, gain economical revenue while averting destruction of unspoiled regions and aesthetic impairment. We recommend strict environmental legislation involving use of the “polluter pay principle”, continuous monitoring of pollution and establishment of an industry-funded catastrophe trust fund. These initiatives can ensure economic benefits while environmental impacts remain negligible.

In conclusion

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In conclusion

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Knowledge into action: Some lessons from the histories of hazards

When it comes to “Science and Policy to Protect Future Generations”, it has often been the usefulness and reliability of science that has been the centre of attention (See for instance the US National Academy of Sciences ` red, blue and silver reports on risk assessments in 1983, 1993 and 2010, respectively). However, if one looks at history there has often been sufficient science to justify precautionary actions to reduce or eliminate harm from hazardous agents decades before effective regulatory actions was eventually taken. The histories of now well known hazardous chemicals such as PCBs, DDT, lead in petrol, mercury, and benzene provide rich lessons for how more precautionary action could be applied to emerging chemical risks from, for example, BPA, fluorinated compounds, and nicotinoid pesticides. Similarly the histories of well known technologies such as X rays, fishing techniques, fossil fuels and nuclear power provide lessons for prudent actions on the potential hazards of emerging technologies such as from nanotechnology, GMO food, radio-frequency from mobile phones, and the new generation of nuclear plants (See “Late Lessons from Early Warnings” volume I and II from the European Environment Agency 2001 & 2012; Lawless’ original work from 1972 on “Technology and Social Shocks”; and recent applications of the Precautionary Principle in the EU e.g. by the Danish authorities on phthalates). These past and current narratives about both certain and uncertain hazards show that timely actions to reduce harm have not been thwarted by inadequate science (though there examples of that) but mainly by two sets of societal barriers: opposition from corporate and political interests that benefit from the status quo, and specific economic, social, and cultural barriers to the use of knowledge in justifying timely actions. The latter include intransparent and inadequate evaluations of the science; weak but politically effective argumentation; market prices that do not reflect full costs of production and use of hazardous products; inadequate reporting by the media; and limited awareness and engagement of the public. In this paper, we analyse these latter barriers to getting knowledge into action and illustrate some ways and means by which science and precautionary measures, including regulations, market based instruments, and increased awareness and engagement of the public, could be designed and implemented in order to shorten the time between the first plausible scientific evidence of harm and the first initiatives on reducing hazards and risks.

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Late lessons from early warnings: science, precaution, innovation

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Nanomaterials: Regulation and Risk Assessment

The topics of regulation and risk assessment of nanomaterials have never been more relevant and controversial in Europe than they are at this point in time. In this entry, we present and discuss a number of major pieces of legislation relevant for the regulation of nanomaterials, including REACH, the Water Framework Directive, pharmaceuticals regulation, and the Novel Foods Regulation. Current regulation of nanomaterials entail three overall challenges: 1) limitations in regard to terminology and definitions of key terms such as a “substance,” “novel food,” etc.; 2) safety assessment requirements triggered by thresholds values not tailored to the nanoscale but based on bulk material; and 3) limitations related to lack of metrological tools, (eco)toxicological data, and environmental exposure limits as required by, e.g., REACH, the pharmaceuticals regulation, and the recast of the Novel Foods Regulation. Chemical risk assessment provides a fundamental element in support of existing legislation. Risk assessment is normally said to consist of four elements, i.e., hazard identification, dose–response assessment, exposure assessment, and risk characterization. Each of these four elements hold a number of limitations specific to nanomaterials, i.e., the fact that mass might not be the proper metric to describe the dose in dose–response assessment. These limitations are not easily overcome despite the fact that a lot of effort is being put into investigating the applicability of each of these four elements.


Nanotechnology, the science and application of objects smaller than 100 nanometres, is evolving rapidly in many fields. Besides the countless beneficial applications, including in health and medicine, concerns exist on adverse health consequences of unintended human exposure to nanomaterials.

In the 2010 Parma Declaration on Environment and Health, ministers of health and of environment of the 53 Member States of the WHO Regional Office for Europe listed the health implications of nanotechnology and nanoparticles among the key environment and health challenges.

The WHO Regional Office for Europe undertook a critical assessment of the current state of knowledge and the key evidence on the possible health implications of nanomaterials, with a view to identify options for risk assessment and policy formulation, and convened an expert meeting to address the issue.

Current evidence is not conclusive. As complexity and uncertainty are large, risk assessment is challenging, and formulation of evidence-based policies and regulations elusive. Innovative models and frameworks for risk assessment and risk governance are being developed and applied to organize the available evidence on biological and health effects of nanomaterials in ways to inform policy.
Operationalization and application of "early warning signs" to screen nanomaterials for harmful properties

In 2001 the European Environment Agency (EEA) published a report that analyzed 14 cases of technological developments that later on turned out to have negative side-effects and they identified 12 "late lessons" for current and future policy-makers to bear in mind when initiating new technological endeavors. This paper explores how the first lesson – "Acknowledge and respond to ignorance, uncertainty and risk in technology appraisal" could be applied to screen nanomaterials. In cases of ignorance, uncertainty and risk, the EEA recommends paying particular attention to important warning signs such as novelty, persistency, whether materials are readily dispersed in the environment, and whether they bioaccumulate or lead to potentially irreversible action. Through an analysis of these criteria using five well-known nanomaterials (titanium dioxide, carbon nanotubes, liposomes, poly(lactic-co-glycolic acid) and nanoscale zero-valent iron), it was found that only nanoTiO2 fulfils all the five criteria. Depending on the length of the nanotubes, carbon nanotubes fulfil 3 or 4 criteria whereas liposomes, poly(lactic-co-glycolic acid), nanoscale zero-valent iron fulfil only one criteria. Finally, we discuss how these warning signs can be used by different stakeholders such as nanomaterial researchers and developers, companies and regulators to design benign nanomaterials, communicate what is known about nano-risks and decide on whether to implement precautionary regulatory measures.

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Operationalization and application of "early warning signs" to screen nanomaterials for harmful properties

In 2001 the European Environment Agency (EEA) published a report that analyzed 14 cases of technological developments that later on turned out to have negative side-effects and they identified 12 "late lessons" for current and future policy-makers to have in mind when initiating new technological endeavors. This paper explores how the first lesson - "Acknowledge and respond to ignorance, uncertainty and risk in technology appraisal" could be applied to screen nanomaterials. In cases of ignorance, uncertainty and risk, the EEA recommends paying particular attention to important warning signs such as novelty, persistency, whether materials are readily dispersed in the environment, whether they bioaccumulate or lead to potentially irreversible action. Through an analysis of these criteria using five well-known nanomaterials (titanium dioxide, carbon nanotubes, liposomes, poly(lactic-co-glycolic acid) and nanoscale zero-valent iron, and carbon nanotubes), it was found that only nanoTiO2 fulfills all the five criteria. Dependent on the length of the nanotubes, carbon nanotubes fulfills 3 or 4 criteria whereas liposomes, poly(lactic-co-glycolic acid), nanoscale zero-valent iron fulfills only one criteria. Finally, we discuss how these warning signs can be used by different stakeholders such as nanomaterial researchers and developers, companies and regulators to design benign nanomaterials, communicate what is known about nano-risks and decide on whether to implement precautionary regulatory measures.

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Operationalization and application of "early warning signs" to screen nanomaterials for harmful properties

In 2001 the European Environment Agency (EEA) published a report that analyzed 14 cases of technological developments that later on turned out to have negative side-effects and they identified 12 "late lessons" for current and future policy-makers to have in mind when initiating new technological endeavors. This paper explores how the first lesson - "Acknowledge and respond to ignorance, uncertainty and risk in technology appraisal" could be applied to screen nanomaterials. In cases of ignorance, uncertainty and risk, the EEA recommends paying particular attention to important warning signs such as novelty, persistency, whether materials are readily dispersed in the environment, whether they bioaccumulate or lead to potentially irreversible action. Through an analysis of these criteria using five well-known nanomaterials (titanium dioxide, carbon nanotubes, liposomes, poly(lactic-co-glycolic acid) and nanoscale zero-valent iron, and carbon nanotubes), it was found that only nanoTiO2 fulfills all the five criteria. Dependent on the length of the nanotubes, carbon nanotubes fulfills 3 or 4 criteria whereas liposomes, poly(lactic-co-glycolic acid), nanoscale zero-valent iron fulfills only one criteria. Finally, we discuss how these warning signs can be used by different stakeholders such as nanomaterial researchers and developers, companies and regulators to design benign nanomaterials, communicate what is known about nano-risks and decide on whether to implement precautionary regulatory measures.

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Pro et con analysis of existing ranking and occupational risk assessment concepts for Nanomaterials

There is an urgent need for adaptive, transparent, easy comprehensible and communicational and yet robust scientific methods, approaches and frameworks to evaluate the potential of exposure, hazard and risk related to the production and application of nanomaterials. A number of alternatives or supplements to traditional risk assessment have been explored and proposed in recent years. Examples of these include the “Control Banding Nanotool” developed to assess and control the risks of nanomaterials and the more holistic “Swiss precautionary matrix”. In this paper we review these and other tools and discuss various elements of the tools (input data requirements, risk evaluation and risk handling) as well as pros and cons. We find that most of the tools provide a transparent and comprehensible approach and a few include risk management and communication going well beyond what is normally considered in traditional risk assessment. Most of the concepts available today however, is that their input data requirements are fairly high and some of the scientific information needed in order to apply them is inconclusive at the moment or non-existing. Some of the concepts are furthermore based on purely theoretical considerations and time-consuming to apply in reality. We provide a set of recommendations for what regulators and risk assessors need to consider before selecting and applying one or the other tool in a given situation and call for further application and development of these tools in the support regulatory decision-making.

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The environmental, social and ethical aspects of multinational corporations exploiting oil resources in Ecuador

Extraction of oil promises economic growth in many developing countries but almost inevitably brings environmental and social degradation with it. In this paper we explore the environmental, social and ethical aspects of multinational companies’ (MNCs) oil exploration and production in Ecuador and we analyze several different protective regulatory management strategies that could help eliminate negative impacts. We use Drivers Pressures State Impacts Responses (DPSIR)-analysis to understand the interconnectivity of the current situation whereas we use stakeholder analysis to identify the most appropriate regulatory response. We find that there is scientific consensus that pollution from oil production by MNCs has caused an environmental disaster, a widespread health emergency and serious detrimental social impacts. This raises fundamental questions about whether it is ethically justifiable that MNCs disregard legal rules from their country of origin to profit from limited and ineffective environmental law in developing countries. A number of regulatory strategies exist that could resolve the situation including; the temporary banning of MNCs to extract oil, expansion of the Yasuní-ITT initiative, which allows the Ecuadorian government to receive funds from the international community for refraining from oil exploitation, compensation and remediation and the development of environmental law and policy. Selecting the most appropriate strategies exist that could resolve the situation including; the temporary banning of MNCs to extract oil, expansion of the Yasuní-ITT initiative, which allows the Ecuadorian government to receive funds from the international community for refraining from oil exploitation, compensation and remediation and the development of environmental law and policy. Selecting the most appropriate strategies requires stakeholder involvement and consideration of their interests. Through our stakeholder analysis we identified a wide range of stakeholders ranging from the indigenous people to MNCs such as Chevron. The interests, influence and political and economical power of the identified stakeholders differ substantially and unfortunately it was found that the most impacted stakeholders were quite often the least influential. We recommend that a heavy focus is put on the use and implementation of the ‘precautionary’ principle and the ‘polluter pays’ principle and that public participation is encouraged to provide a legal framework to support sustainable development in Ecuador. © 2013 WIT Press.

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
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The European Union's chemical legislation needs revision

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Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Hansen, S. F.
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Web of Science (2017): Impact factor 37.49
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Scopus rating (2016): CiteScore 21.85 SJR 18.916 SNIP 7.649
Web of Science (2016): Impact factor 38.986
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 22.1 SJR 18.842 SNIP 8.019
Web of Science (2015): Impact factor 35.267
Web of Science (2015): Indexed yes
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Scopus rating (2014): CiteScore 21.76 SJR 17.177 SNIP 8.047
Web of Science (2014): Impact factor 34.048
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Scopus rating (2013): CiteScore 21.94 SJR 16.688 SNIP 7.784
Web of Science (2013): Impact factor 33.265
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 17.55 SJR 15.706 SNIP 7.569
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ISI indexed (2012): ISI indexed yes
The precautionary principle and false alarms — lessons learned

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Hansen, S. F., Tickner, J. A.
Pages: 12
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Host publication information
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Publisher: European Environment Agency
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URLs:
Source: dtu
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Research output: Research › Book chapter – Annual report year: 2013

Virkemidler til sikker håndtering af nanomaterialer - debatpjece med anbefalinger

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Danish Technological Institute
Contributors: Vejen Kristensen, H., Nørskov, E., Hansen, S. F., Baun, A.
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VITAL nano - Nye virkemidler til sikker håndtering af nanomaterialer: Slutrapport

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Organisations: Department of Environmental Engineering, Environmental Chemistry, Danish Technological Institute
Contributors: Vejen Kristensen, H., Baun, A., Hansen, S. F.
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Environmental Exposure to Nanomaterials – Data Scoping Study: Final Report

General information
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Contributors: Ganzleben, C., Hansen, S. F.
Number of pages: 193
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Research output: Research › Report – Annual report year: 2013

Environmental risk analysis for nanomaterials: Review and evaluation of frameworks
In response to the challenges of conducting traditional human health and ecological risk assessment for nanomaterials (NM), a number of alternative frameworks have been proposed for NM risk analysis. This paper evaluates various risk analysis frameworks proposed for NM based on a number of criteria. Among other results, most frameworks were found to be flexible for multiple NM, suitable for multiple decision contexts, included life cycle perspectives and precautionary aspects, transparent and able to include qualitative and quantitative data. Nevertheless, most frameworks were primarily applicable to occupational settings with minor environmental considerations, and most have not been thoroughly tested on a wide range of NM. Care should also be taken when selecting the most appropriate risk analysis strategy for a given risk context. Given this, we recommend a multi-faceted approach to assess the environmental risks of NM as well as increased applications and testing of the proposed frameworks for different NM.

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State: Published
Organisations: Safety, Reliability and Human Factors, Department of Management Engineering, Environmental Chemistry, Department of Environmental Engineering
Contributors: Grieger, K. D., Linkov, I., Hansen, S. F., Baun, A.
Pages: 196-212
Publication date: 2012
Peer-reviewed: Yes
European regulation affecting nanomaterials – review of limitations and future recommendations

After learning about the potential risks associated with various specific nanomaterials, concerns have been raised about adequacy of existing regulation in Europe and what should be done to address any potential regulatory gaps related to nanomaterials. Understanding the limitations of the current regulation in regard to nanomaterials is a starting point in a democratic and transparent process towards adapting existing laws and facilitating an informed discussion about which kind of regulatory options best address the identified limitations. In the following we will introduce key pieces of European...
legislation affecting nanomaterials, analyze their limitations, and provide a number of recommendations on how these can be overcome. We find that, although nanomaterials are in principle covered by the scope of many of the existing legislative frameworks, it is often unclear, if current regulations are actually applicable when it comes to specific nanomaterials and their diverse applications. Main limitations seem to be: that requirements to do safety evaluations are triggered by production volumes by tonnage not tailored to the nanoscale, the profound lack of (eco)toxicological data, and that thresholds values and occupational exposure limits cannot be established with existing methodologies.

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Contributors: Hansen, S. F., Baun, A.
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Scopus rating (2017): CiteScore 3.15 SJR 0.959 SNIP 0.991
Web of Science (2017): Impact factor 2.435
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.09 SJR 0.818 SNIP 0.716
Web of Science (2016): Impact factor 2.088
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.09 SJR 0.781 SNIP 0.707
Web of Science (2015): Impact factor 1.855
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.32 SJR 0.339 SNIP 0.422
Web of Science (2014): Impact factor 1.217
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.67 SJR 0.429 SNIP 0.66
Web of Science (2013): Impact factor 1.234
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.07 SJR 0.686 SNIP 0.928
Web of Science (2012): Impact factor 1.5
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.89 SJR 0.584 SNIP 0.931
Web of Science (2011): Impact factor 1.915
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.501 SNIP 1.058
Web of Science (2010): Impact factor 2.895
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.333 SNIP 0.441
BFI (2008): BFI-level 1
Horizon-scanning and Identification of Emerging Risks among Nanotech-companies

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Organisations: Department of Environmental Engineering, Environmental Chemistry, Danish Technological Institute
Contributors: Hansen, S. F., Vejen Kristensen, H., Baun, A.
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Nanodatabasen - new Danish product inventory

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Nanomaterials as priority substances under the Water Framework Directive

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Nanoparticles: Uncertainty Risk Analysis

Scientific uncertainty plays a major role in assessing the potential environmental risks of nanoparticles. Moreover, there is uncertainty within fundamental data and information regarding the potential environmental and health risks of nanoparticles, hampering risk assessments based on standard approaches. To date, there have been a number of different approaches to assess uncertainty of environmental risks in general, and some have also been proposed in the case of nanoparticles and nanomaterials. In recent years, others have also proposed that broader assessments of uncertainty are also needed in order to handle the complex potential risks of nanoparticles, including more descriptive characterizations of uncertainty. Some of these approaches are presented and discussed herein, in which the potential strengths and limitations of these approaches are identified along with further challenges for assessing uncertainty pertaining to the potential environmental risks of nanoparticles. Currently, international research efforts are underway not only to assess these uncertainties but also to handle the embedded uncertainties within assessing the potential environmental risks of nanoparticles. However, it is clear that further research efforts are needed to sufficiently handle the extensive uncertainties associated with nanoparticle risks, given the diversity of materials, pace of innovation, and various environmental parameters to consider.

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Contributors: Grieger, K. D., Hansen, S. F., Baun, A.
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URLs:
http://www.crcpress.com/product/isbn/9781439829271

Research output: Research - peer-review › Journal article – Annual report year: 2012

Nanotechnology and Human Health: Scientific Evidence and Risk Governance

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Organisations: Department of Environmental Engineering, Environmental Chemistry, World Health Organization, Ulster University, RTI International
Contributors: Martuzzi, M., Hansen, S. F., Howard, V., Grieger, K.
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Pro et con analysis of existing ranking and occupational risk assessment concepts for nanomaterials

General information
State: Published
Pro Et Con Analysis Of Occupational Exposure Assessment Tools And Concepts For nanomaterials

There is an urgent need for simple and yet robust scientific methods to evaluate the potential of occupational exposure related to the production and application of nanomaterials. A number of alternatives to traditional exposure assessment have recently been explored and proposed for nanomaterials. Examples of these include the "Control Banding Nanotool" developed to assess and control the risks of nanomaterials, the more holistic "Swiss precautionary matrix", and the first order quantitative risk assessment tool, NanoSafer. Here we review these and other tools and we discuss various elements of the tools (input data requirements, exposure evaluation and handling to reduce exposure) as well as specific pros and cons. Most of the tools provide a transparent and comprehensible approach to assess occupational exposure, but the majority of them are based on purely qualitative considerations about occupational settings. A few methods include specific advice on risk management going well beyond what is normally considered in traditional exposure assessment. A disadvantage in most of the existing concepts is that their data requirements are fairly high. In some cases the technical and scientific procedures to determine them is inconclusive or non-existing. Some of the concepts are furthermore based on purely theoretical considerations and too time-consuming to apply in reality. We provide a set of recommendations for what regulators and risk assessors need to consider before selecting and applying one or the other tool in a given situation and call for further application and development of these tools in the support regulatory decision-making. The aim should be to develop a tiered approach with a purely qualitative, a semi-quantitative, and purely quantitative tool, respectively which can be employed depending on available data and user background. See figure 1 for an illustration of how this could be envisioned in regard to the on-going development of the Danish NanoSafer tool.

Review of the Risks Posed to Drinking Water by Man-Made Nanoparticles

There is increasing concern over the health effects of engineered nanoparticles (ENPs). Humans can be exposed to these particles directly during product use or indirectly following release to the natural environment. One potential indirect exposure route is through the consumption of contaminated drinking waters. In order to address these concerns, the U.K. Drinking Water Inspectorate (DWI) has published a "Review of the risks posed to drinking water by man-made nanoparticles"(DWI 70/2/246). The study, which was funded by the Department for Food and Rural Affairs (Defra), was undertaken by the Food and Environment Research Agency (Fera) in collaboration with a multi-disciplinary team of experts including Rob Aitken, Steve Hankin and Gordon Fern of the Institute of Occupational Medicine (IOM)/SAFENANO.

The study explored the potential for ENPs to contaminate drinking water supplies and to establish the significance of the drinking water exposure route compared to other routes of exposure. Risk was examined in the sense of likelihood of exposure to nanoparticles via drinking water; analysis of health risks was beyond the scope of the project.

The first stage of the study consisted of a detailed review of the occurrence and quantities of ENPs in different product types as well as possible release scenarios (direct & indirect release to air, soil and water), their possible fate and behaviour in raw water and during drinking water treatment. Based on the available data, ENPs that are likely to reach water sources (such as ENPs that are produced in large quantities or are used in a free form) were identified and
categorised. The classification was based on a categorisation framework to aid exposure assessment of nanomaterials in consumer products.

A conservative approach was then used to estimate worst case concentrations of ENPs in raw water and treated drinking water, using a simple exposure model. Exposure estimates for raw water and treated drinking water were then qualitatively compared to available estimates for human exposure through other routes, e.g. direct exposure from consumer products. This allowed an estimate of the amount of exposure to a range of ENPs from drinking water as well as a relative qualitative risk of exposure to ENPs from drinking water compared to other routes.

A range of metal, metal oxide and organic-based ENPs were identified that have the potential to contaminate drinking waters. Worst case predicted concentrations in drinking waters were in the low to sub-µg/l range and more realistic estimates were tens of ng/l or less. For the majority of product types, human exposure via drinking water is predicted to be less important than exposure via other routes. The exceptions were some clothing materials, paints and coatings and cleaning products. The particles contained in these products include Ag, Al, TiO2, Fe2O3 and carbon-based materials. Although predicted concentrations of these materials in UK drinking water are low, the authors of the report recommend that any future work on risks of ENPs to drinking waters should probably focus on these materials and the development of the UK market for products containing these materials.

Based on the outcome of this study, the authors conclude that there are significant gaps in our current knowledge regarding the use, environmental fate and exposure of ENPs in the UK environment and the report includes recommendations for future studies. The authors also note that this is a product by product analysis and does not reflect human exposure at an individual level.

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**When enough is enough**

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
A way forward in exposure assessment of nanomaterials in the aquatic environment

The current approach to ecological risk assessment of chemicals is based on the quotient of a predicted no effect concentration and a predicted exposure concentration. We have gathered knowledge supporting the prediction of the exposure concentration of nanomaterials (NMs) in the aquatic environment and have evaluated the adequacy of the current guidance documents for use with NMs and therefore have also conducted a literature review on two important environmental fate processes for NMs, sedimentation and dissolution. This resulted in an overview of the available
quantitative data for sedimentation and dissolution of NMs. We have used this overview to propose a way forward in modeling the exposure concentration of NMs in the water phase. Transport to sediment seems to be of greater relative importance than advection or dissolution of NMs. Both the transport of nanomaterials from water to sediment and the dissolution of nanomaterials can be incorporated into current exposure models simply by adding first-order rate constants. Our proposed exposure model for nanomaterials can be used to improve current risk assessment for nanomaterials.

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Organisations: Department of Environmental Engineering, Environmental Chemistry, National Institute of Public Health and the Environment, Radboud University Nijmegen
Contributors: Quik, T. K., Vonk, A., Hansen, S. F., Baun, A., van de Meent, D.
Number of pages: 79
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Chemical Risk Assessment of nanomaterials- Limitations and potential alternatives

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Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Hansen, S. F.
Publication date: 2011
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Electronic versions:
steffen.pdf
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Source-ID: 312339
Research output: Research › Conference abstract for conference – Annual report year: 2011

Conceptual modeling for identification of worst case conditions in environmental risk assessment of nanomaterials using nZVI and C60 as case studies

Conducting environmental risk assessment of engineered nanomaterials has been an extremely challenging endeavor thus far. Moreover, recent findings from the nano-risk scientific community indicate that it is unlikely that many of these challenges will be easily resolved in the near future, especially given the vast variety and complexity of nanomaterials and their applications. As an approach to help optimize environmental risk assessments of nanomaterials, we apply the Worst-Case Definition (WCD) model to identify best estimates for worst-case conditions of environmental risks of two case studies which use engineered nanoparticles, namely nZVI in soil and groundwater remediation and C60 in an engine oil lubricant. Results generated from this analysis may ultimately help prioritize research areas for environmental risk assessments of nZVI and C60 in these applications as well as demonstrate the use of worst-case conditions to optimize future research efforts for other nanomaterials. Through the application of the WCD model, we find that the most probable worst-case conditions for both case studies include i) active uptake mechanisms, ii) accumulation in organisms, iii) ecotoxicological response mechanisms such as reactive oxygen species (ROS) production and cell membrane damage or disruption, iv) surface properties of nZVI and C60, and v) acute exposure tolerance of organisms. Additional estimates of worst-case conditions for C60 also include the physical location of C60 in the environment from surface run-off, cellular exposure routes for heterotrophic organisms, and the presence of light to amplify adverse effects. Based on results of this analysis, we recommend the prioritization of research for the selected applications within the following areas: organism active uptake ability of nZVI and C60 and ecotoxicological response end-points and response mechanisms including ROS production and cell membrane damage, full nanomaterial characterization taking into account detailed information on nanomaterial surface properties, and investigations of dose–response relationships for a variety of organisms.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Aarhus University
Contributors: Grieger, K. D., Hansen, S. F., Sørensen, P. B., Baun, A.
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Publication information
Critical analysis of frameworks and approaches to assess the environmental risks of nanomaterials

7.1.7 Critical analysis of frameworks and approaches to assess the environmental risks of nanomaterials Khara D. Grieger1, Igor Linkov2, Steffen Foss Hansen1, Anders Baun1 1Technical University of Denmark, Kgs. Lyngby, Denmark 2Environmental Laboratory, U.S. Army Corps of Engineers, Brookline, USA Email: kdg@env.dtu.dk Scientists, organizations, governments, and policy-makers are currently involved in reviewing, adapting, and formulating risk assessment frameworks and strategies to understand and assess the potential environmental risks of engineered nanomaterials (NM). It is becoming increasingly apparent that approaches which are aimed at ultimately fulfilling standard, quantitative environmental risk assessment for NM is likely to be not only extremely challenging but also resource- and time-consuming. In response, a number of alternative or complimentary frameworks and approaches to standard (environmental) risk assessment have been subsequently proposed specifically for NM. However, further information regarding the potential strengths and weaknesses of these strategies is currently lacking. This analysis aims to evaluate different environmental risk analysis or assessment frameworks and approaches which have been developed or proposed by large organizations or regulatory bodies for NM. These frameworks and approaches were evaluated and assessed based on a select number of criteria which have been previously proposed as important parameters for inclusion in successful risk assessment frameworks for NM: flexible for a variety of NM, suitable for multiple decision contexts, incorporate uncertainty analysis, include life cycle perspectives, iterative or adaptive, enable more timely decision making, transparent, integrate various stakeholder perspectives, integrate precaution, and include qualitative or quantitative data. Among other results we find that most of the investigated frameworks and approaches are i) flexible for multiple NM, ii)
suitable for multiple decision contexts, iii) include life cycle perspectives, iv) transparent, v) include precautionary aspects, and vi) able to include qualitative and quantitative data. We also find that many of the frameworks and approaches may be adapted for iterative or adaptive elements and timely decision making if needed, although these criteria were not inherently embedded in many of the strategies based on their current format. Furthermore, most frameworks and approaches are mainly applicable to occupational settings with minor applications for the environment, and many (if not most) of them have not been thoroughly tested on a wide range of NM or nano-applications. Given these results, we recommend the use of a multi-faceted approach to assess the environmental risks of NM, in which different frameworks may be used and combined for the particular question considered. We also recommend further testing of these different frameworks and approaches on concrete, real-world NM applications which are specifically relevant for environmental risk contexts.

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Source: orbit
Source-ID: 286312
Research output: Research - peer-review; Poster – Annual report year: 2011

How to assess exposure of aquatic organisms to manufactured nanoparticles?
Ecological risk of chemicals is measured by the quotient of predicted no-effect concentrations and predicted exposure concentrations, which are hard to assess for manufactured nanomaterials (NMs). This paper proposes modifications to currently used models, in order to make them suitable for estimating exposure concentrations of NMs in the aquatic environment. We have evaluated the adequacy of the current guidance documents for use with NMs and conclude that nano-specific fate processes, such as sedimentation and dissolution need to be incorporated. We have reviewed the literature on sedimentation and dissolution of NMs in environmentally relevant systems. We deduce that the overall kinetics of water–sediment transport of NMs should be close to first order. The lack of data on dissolution of NMs under environmentally realistic conditions calls for a pragmatic decision on which rates to be used in modeling. We find that first order removal kinetics for dissolution seems adequate. Based on limited data from literature, probable removal rates range from 0 to 10−4s−1 for sedimentation, and from 0 to 10−5s−1 for dissolution. Further experimental data at environmentally relevant conditions for sedimentation and dissolution of NMs is needed.

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Scopus rating (2017): CiteScore 7.32 SJR 2.568 SNIP 2.211
Web of Science (2017): Impact factor 7.297
Web of Science (2017): Indexed yes
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Source-ID: 278899
Research output: Research - peer-review › Journal article – Annual report year: 2011
NanoRisk - A Conceptual Decision Support Tool for Nanomaterials
Only a few risk assessment methodologies and approaches are useful for assessing the risk for professional end-users, consumers and the environment. We have developed a generic framework (NanoRiskCat) that can be used by companies and risk assessors to categorize nanomaterials considering existing environmental, health and safety information and known uncertainties. In NanoRiskCat’s simplest form, the final evaluation outcome for a specific nanomaterial in a given application will be communicated in the form of a short title (e.g. TiO2 in sunscreen) describing the use of the nanomaterial. This short title is followed by a color code where the first three colored bullets always refer to potential exposure of professional end-users, consumers and the environment in that sequence and the last two colored bullets always refer to the hazard potential for humans and the environment. The colors assigned to the exposure and hazard potential are green, yellow corresponding to none, possible, expected and unknown, respectively. The exposure potential was evaluated based on 1) the location of the nanomaterial and 2) a judgment of the potential of nanomaterial exposure based on the description and explanation of each process, category, etc. The hazard potential for humans is evaluated based on whether the nanomaterial in question is known as a compound to have low solubility in water (biodurable); fulfil the fiber paradigm; be regulated harder than nuisance materials, to have CMR-properties or other adverse effects? The environmental hazard potential is based on whether the nanomaterial in question is known to be: readily dispersed, persistent, bioaccumulative, and/or has been reported to be hazardous to environmental species.

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NanoRiskCat – a conceptual decision support tool for nanomaterials

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Source-ID: 314529
Research output: Research › Report – Annual report year: 2011

Nanowaste: Business-As-Usual Or A New Challenge For The Waste Industry?
Manufacturing of products containing engineered nanomaterials is growing quickly, and more than 1000 of these products can be already found on the market today. However, the nanowaste issue lacks quite completely of basic knowledge and information. In the present study, we provided a definition of nanowaste and developed classification and quantification methods. In addition, we discussed the usability of available analytical techniques for characterization of nanowaste. Based on three case studies, we showed that nanowaste generation is already in the order of thousand of Mg in 2011, meaning that the nanowaste issue should not be neglected any longer. We conclude the analysis providing the waste industry, research institutions and policy makers with recommendations for future work to be done in order to properly deal with nanowaste in an environmentally sound way.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, National Research Centre for the Working Environment
Contributors: Hansen, S. F., Baun, A., Alstrup-Jensen, K.
Number of pages: 261
Publication date: 2011
Specific Advice on Exposure Assessment and Hazard/Risk Characterisation for Nanomaterials under REACH (RIP-oN 3) - Final Project Report

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Number of pages: 238
Publication date: 2011

Publication information
Publisher: European Commission
Original language: English
Electronic versions:
prod21321295687236.Aitken-1.pdf
URLs:
Source: orbit
Source-ID: 312432
Research output: Research › Report – Annual report year: 2011

Specific Advice on Fulfilling Information Requirements for Nanomaterials under REACH (RIP-oN 2) – Final Project Report

The European Commission (EC) began in 2009 a Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) Implementation Project on Nanomaterials (RIPoN), which it intended to provide advice on key aspects of the implementation of REACH with regard to nanomaterials.

General information
State: Published

Survey on basic knowledge about exposure and potential environmental and health risks for selected nanomaterials

Based on a literature review this report provides a general description as well as an environmental and health profile of 7 nanomaterials. The examined nanomaterials are selected because of expected high use or specific environmental and health properties. Fullerenes, iron, silver, nanoclay and titanium-, cerium-, and silicondioxides were studied in the project. Based on current uses, it is concluded that current applications of nano-iron and nanoclay can not cause unexpected "nano-associated" health or environmental problems. Although no specific risk associated with current uses of any of the 7 other nanomaterials were identified, there are areas where there may be reason for attention and thus need for more knowledge.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Division of Toxicology and Risk Assessment, National Food Institute, COWI AS
Contributors: Mikkelsen, S. H., Hansen, E., Christensen, T. B., Baun, A., Hansen, S. F., Binderup, M.
Number of pages: 136
Publication date: 2011

Towards a nanorisk appraisal framework

The article discusses, in the context of nanotechnology, whether current concepts of chemical risk assessment can be used to assess nanorisk. Nanorisk can be defined from the narrow (eco)toxicological perspective to the broader sense to include societal/cultural impacts or even to the fundamental philosophical level, i.e. questioning societies need for the technology. We outline here the limitations of chemical risk assessment and other recent proposed risk governance paradigms in relation to nanotechnology and nanomaterials, including its inability to include societal risks (ownership, privacy, security, nanodivide, 1 convergence of nano-, bio-, etc.) and metaphysical risk (including the lay persons perspective on the risks of nanotechnology). Finally, we outline the fundamental principles and criteria that an alternative comprehensive framework should be based on.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Monash University
Contributors: Senjen, R., Hansen, S. F.
Pages: 637
Publication date: 2011
Peer-reviewed: Yes
A global view of regulations affecting nanomaterials

The 2000s have been characterized by an unprecedented exploration into research and development of nanotechnology and nanomaterials. Despite a slow start, new regulatory initiatives are popping up like mushrooms internationally. Many of these initiatives have yet to materialize themselves or are soft law initiatives, and their impact on the development of more authoritative and prescriptive regulatory measures is most likely to be limited. This is due to a number of transnational regulatory challenges that include: (1) whether to adapt existing legislation or develop a new regulatory framework, (2) whether nanomaterials should be considered as different from their bulk counterparts, (3) how to define nanotechnology and nanomaterials, and (4) how to deal with the profound limitations of risk assessment when it comes to nanomaterials. In this opinion, I discuss these and related issues and conclude that the development of a new authoritative and prescriptive regulatory framework might be the only way to effectively address these challenges while ensuring a transparent and informed decision-making process. Copyright © 2010 John Wiley & Sons, Inc.

Assessing the Environmental Risks of Nanomaterials: A Comparison of Risk Assessment Frameworks

Assessing the environmental risks of engineered nanomaterials (NM) is currently an intensely contested subject among scientists, organizations, governments, and policymakers. The shear number, variety, and market penetration of NM in consumer goods and other applications, including environmental remediation and sustainable nanotechnologies like solar cells, is increasing at an exponential pace and is expected to continue to grow in coming years and decades. At the same time, it is not yet clear whether traditional chemical risk assessment-based frameworks are suitable for these emerging NM due to a wide range of technical limitations. For instance, serious knowledge gaps remain within e.g. the detection of...
NM in the environment, developing adequate testing equipment and protocols, and toxicity endpoints (Grieger et al., 2009). In the past few years, many scientists and organizations have subsequently outlined research needs as well as some of the different modifications needed to adapt traditional chemical-based risk assessment frameworks to NM. Meanwhile others have also cited some perhaps deep and fundamental limitations of traditional risk assessment frameworks for NM, and have subsequently proposed the use of other risk assessment tools and frameworks (Grieger et al., 2009- submitted.). In the present work, we compare different environmental risk assessment and analysis frameworks proposed for NM, including multicriteria decision analysis, comprehensive environmental assessment, and Nano Risk Framework. These frameworks are assessed according to a number of criteria (10 in total) which have been previously proposed as important parameters to a successful (environmental) risk assessment for NM: comprehensiveness, overall utility, ensuring correct problem formulation, treatment of uncertainty, degree of precaution, inclusion of quantitative or qualitative data, inclusion of life-cycle perspective, iterative and/or adaptive, ensuring timely decision making, and degree of transparency. This analysis can ultimately assist scientists, government agencies, organizations, and other decisionmakers better decide on which risk assessment/analysis framework may be best suited for the specific risk decision at hand. Among other results, we find that while many of the assessed frameworks have their advantages along with limitations, most may require potentially lengthy decision-making processes for NM risk assessments, which is not favourable considering the current pace of NM development. We recommend the use of a multifaceted approach to assessing the environmental risks of NM, in which different risk assessment frameworks and/or tools may be used and combined for the particular question considered. Furthermore, we recommend the use of biomonitoring in some environmental ‘hot spots’ to serve as early warning detectors while the field of NM environmental risk assessment matures, as recommended in our previous work. Ultimately, this analysis may aid the advancement of environmental risk assessment of NM by comparing and documenting the applicability of different risk frameworks for NM in a transparent way and consequently ensuring that present and forthcoming environmental risk assessments and analyses include state of the art knowledge and considerations.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Grieger, K. D., Hansen, S. F., Baun, A.
Publication date: 2010
Peer-reviewed: Yes
Event: Abstract from Environmental Decisions: Risks and Uncertainties, Monte Verità, Switzerland, .
Source: orbit
Source-ID: 260278
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2010

Engineered nanoparticles: Review of health and environmental safety (ENRHES), Project Final Report

General information
State: Published
Organisations: Department of Environmental Engineering
Number of pages: 408
Publication date: 2010

Publication information
Publisher: European Commission
Original language: English
URLs:
Source: orbit
Source-ID: 257131
Research output: Research - peer-review › Report – Annual report year: 2010

Multicriteria mapping of stakeholder preferences in regulating nanotechnology

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Hansen, S. F.
Pages: 1959-1970
Publication date: 2010
Peer-reviewed: Yes
Nanomaterialer – er de farlige?

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Baun, A., Hartmann, N. I. B., Grieger, K. D., Hansen, S. F.
Pages: 30-32
Publication date: 2010
Peer-reviewed: No

Publication information
Journal: Aktuel Naturvidenskab
Issue number: 3
ISSN (Print): 1399-2309
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Source: orbit
Source-ID: 264245
Research output: Research - Journal article – Annual report year: 2010

Nanomaterialer, miljøkemi og økotoksikologi. Kan vi forudse det uforudsete?

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Baun, A., Hansen, S. F.
Number of pages: 172
Pages: 149-166
Publication date: 2010

Host publication information
Title of host publication: Aspekter af dansk miljøkemis historie
Publisher: Dansk Selskab for Historisk Kemi
ISBN (Print): 8789535340
Source: orbit
Source-ID: 275167
Research output: Research - Book chapter – Annual report year: 2011

Time to regulate nanosilver in consumer products? A comparative analysis of current European regulation of nanosilver and nanozinc-oxide: P61

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Hjorth, R., Overgaard, S., Hansen, S. F., Baun, A.
Number of pages: 53
Publication date: 2010

Host publication information
Regulation and risk assessment of nanomaterials: Too little, too late?

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Hansen, S. F.
Number of pages: 111
Publication date: Apr 2009

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Electronic versions:
WWW version
Source: orbit
Source-ID: 239848
Research output: Research › Ph.D. thesis – Annual report year: 2009

Adopting eco-innovation in Danish polymer industry working with nanotechnology: Drivers, barriers and future strategies

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Safety, Reliability and Human Factors, Department of Management Engineering
Contributors: Kristensen, H., Vinding, K., Hansen, S. F., Grieger, K. D.
Pages: 416-440
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Nanotechnology Law & Business
Volume: 6
ISSN (Print): 1546-203X
Ratings:
Scopus rating (2017): SJR 0.107 SNIP 0.039
Scopus rating (2016): CiteScore 0.19 SJR 0.137 SNIP 0.344
Scopus rating (2015): CiteScore 0.27 SJR 0.133 SNIP 0.243
Scopus rating (2014): CiteScore 0.11 SJR 0.154 SNIP 0.304
Scopus rating (2013): CiteScore 0.14 SJR 0.141 SNIP 0.161
ISI indexed (2013): ISI indexed no
Scopus rating (2012): CiteScore 0.19 SJR 0.147 SNIP 0.135
ISI indexed (2012): ISI indexed no
Scopus rating (2011): CiteScore 0.39 SJR 0.283 SNIP 0.355
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.159 SNIP 0.149
Scopus rating (2009): SJR 0.212 SNIP 0.24
Scopus rating (2008): SJR 0.144 SNIP 0.25
Scopus rating (2007): SJR 0.142 SNIP 0.133
Scopus rating (2006): SJR 0.111 SNIP 1.345
Original language: English
Source: orbit
Source-ID: 252835
Research output: Research › Journal article – Annual report year: 2009
Emerging methods and tools for environmental risk assessment, decision-making, and policy for nanomaterials: summary of NATO Advanced Research Workshop

Nanomaterials and their associated technologies hold promising opportunities for the development of new materials and applications in a wide variety of disciplines, including medicine, environmental remediation, waste treatment, and energy conservation. However, current information regarding the environmental effects and health risks associated with nanomaterials is limited and sometimes contradictory. This article summarizes the conclusions of a 2008 NATO workshop designed to evaluate the wide-scale implications (e.g., benefits, risks, and costs) of the use of nanomaterials on human health and the environment. A unique feature of this workshop was its interdisciplinary nature and focus on the practical needs of policy decision makers. Workshop presentations and discussion panels were structured along four main themes: technology and benefits, human health risk, environmental risk, and policy implications. Four corresponding working groups (WGs) were formed to develop detailed summaries of the state-of-the-science in their respective areas and to discuss emerging gaps and research needs. The WGs identified gaps between the rapid advances in the types and applications of nanomaterials and the slower pace of human health and environmental risk science, along with strategies to reduce the uncertainties associated with calculating these risks.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Pages: 513-527
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Journal of Nanoparticle Research
Volume: 11
Issue number: 3
ISSN (Print): 1388-0764
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.93 SJR 0.528 SNIP 0.603
Web of Science (2017): Impact factor 2.127
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.74 SJR 0.496 SNIP 0.557
Nanomaterials in consumer products

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Nano risk governance: Current developments and future perspectives

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Linkov, I., Satterstrom, F., Monica Jr., J., Hansen, S. F., Davis, T.
Pages: 203-220
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Nanotechnology Law & Business
Volume: 6
ISSN (Print): 1546-203X
Ratings:
Scopus rating (2017): SJR 0.107 SNIP 0.039
Scopus rating (2016): CiteScore 0.19 SJR 0.137 SNIP 0.344
Scopus rating (2015): CiteScore 0.27 SJR 0.133 SNIP 0.243
Scopus rating (2014): CiteScore 0.11 SJR 0.154 SNIP 0.304
Scopus rating (2013): CiteScore 0.14 SJR 0.141 SNIP 0.161
ISI indexed (2013): ISI indexed no
Scopus rating (2012): CiteScore 0.19 SJR 0.147 SNIP 0.135
ISI indexed (2012): ISI indexed no
Scopus rating (2011): CiteScore 0.39 SJR 0.283 SNIP 0.355
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.159 SNIP 0.149
Scopus rating (2009): SJR 0.212 SNIP 0.24
Scopus rating (2008): SJR 0.144 SNIP 0.25
Scopus rating (2007): SJR 0.142 SNIP 0.133
Scopus rating (2006): SJR 0.111 SNIP 1.345
Original language: English
Source: orbit
Source-ID: 247187
Research output: Research - peer-review › Journal article – Annual report year: 2009

Quality assurance for risk assessment of nanomaterials

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Gieger, K. D., Hansen, S. F.
Number of pages: 20
Publication date: 2009

Host publication information
Title of host publication: 1st NanoImpactNet conference for a healthy environment in a future with nanotechnology, Lausanne, Switzerland 23-27 March 2009
Volume: Abstract Book
Place of publication: Lausanne, Switzerland
Risikovurdering i nanodimensioner: Øget anvendelse af nanomaterialer sætter nye krav til risikovurdering

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Baun, A., Hartmann, N. I. B., Grieger, K. D., Hansen, S. F.
Pages: 14-16
Publication date: 2009
Peer-reviewed: Unknown

Publication information
Journal: Dansk Kemi
Volume: 90
Issue number: 3
ISSN (Print): 0011-6335
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Web of Science (2007): Indexed yes
Web of Science (2004): Indexed yes
Original language: Danish
Source: orbit
Source-ID: 240041

Risk assessment as a mean to address the potential risk of nanomaterials - too little, too late?

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Hansen, S. F.
Number of pages: 75
Publication date: 2009

Host publication information
Title of host publication: 1st NanoImpactNet conference for a healthy environment in a future with nanotechnology, Lausanne, Switzerland 23-27 March 2009
Volume: Abstract Book
Place of publication: Lausanne, Switzerland
Publisher: Institute for Work and Health
Source: orbit
Source-ID: 241406
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2009

Setting the limits for engineered nanomaterials in the aquatic environment

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Baun, A., Hartmann, N. I. B., Grieger, K. D., Hansen, S. F.
Number of pages: 19
Publication date: 2009

Host publication information
Title of host publication: 1st NanoImpactNet conference for a healthy environment in a future with nanotechnology, Lausanne, Switzerland 23-27 March 2009
Volume: Abstract book
Setting the limits for engineered nanoparticles in European surface waters - are current approaches appropriate?

**General information**
State: Published
Organisations: Department of Environmental Engineering
Contributors: Baun, A., Hartmann, N. I. B., Grieger, K. D., Hansen, S. F.
Pages: 1774-1781
Publication date: 2009
Peer-reviewed: Yes

**Publication information**
Journal: Journal of Environmental Monitoring
Volume: 11
Issue number: 10
ISSN (Print): 1464-0325
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.84 SJR 1.118 SNIP 0.933
Web of Science (2017): Impact factor 2.491
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.79 SJR 1.036 SNIP 0.967
Web of Science (2016): Impact factor 2.592
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.5 SJR 0.998 SNIP 0.923
Web of Science (2015): Impact factor 2.401
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.21 SJR 1.051 SNIP 1.047
Web of Science (2014): Impact factor 2.179
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.996 SNIP 0.949
Web of Science (2013): Impact factor 2.109
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.023 SNIP 0.87
Web of Science (2012): Impact factor 2.085
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.954 SNIP 0.898
Web of Science (2011): Impact factor 1.991
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.994 SNIP 0.712
The known unknowns of nanomaterials: Describing and characterizing uncertainty within environmental, health and safety risks

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Grieger, K. D., Hansen, S. F., Baun, A.
Pages: 1-12
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Nanotoxicology
Volume: 3
Issue number: 3
ISSN (Print): 1743-5404
Ratings:
Web of Science (2019): Indexed yes
Web of Science (2018): Indexed yes
Scopus rating (2017): CiteScore 5.99
Web of Science (2017): Indexed yes
Scopus rating (2016): CiteScore 5.8
Scopus rating (2015): CiteScore 7.14
Scopus rating (2014): CiteScore 5.92
Scopus rating (2013): CiteScore 6.39
Scopus rating (2012): CiteScore 6.49
Scopus rating (2011): CiteScore 4.77
Web of Science (2009): Indexed yes
Original language: English
Source: orbit
Source-ID: 252210
Research output: Research - peer-review › Journal article – Annual report year: 2009

Categorization framework to aid exposure assessment of nanomaterials in consumer products
Exposure assessment is crucial for risk assessment for nanomaterials. We propose a framework to aid exposure assessment in consumer products. We determined the location of the nanomaterials and the chemical identify of the 580 products listed in the inventory maintained by the Woodrow Wilson International Center for Scholars, of which 37% used nanoparticles suspended in liquids, whereas...
Categorizing Nanomaterials

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Theoretical Atomic-scale Physics, Department of Physics, Innovation and Sustainability, Department of Management Engineering
Contributors: Hansen, S. F., Larsen, B. H., Olsen, S. I., Baun, A.
Publication date: 2008

Host publication information
Volume: CD-ROM
Electronic versions:
ENV2008_038.pdf
Source: orbit
Source-ID: 236821
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2008

Environmental challenges for nanomedicine

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Baun, A., Hansen, S. F.
Environment, health and safety risks of nanomaterials: Research gaps, Recommendations, and government funding

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Grieger, K. D., Hansen, S. F., Baun, A.
Publication date: 2008

Host publication information
Volume: CD-ROM
Source: orbit
Source-ID: 236820
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2008

Implementation of manufactured nanomaterial policy and governance - reflections from a NATO advanced research workshop

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Hakkinen, P., Hansen, S. F., Satterstrom, F., Davis, T.
Number of pages: 79
Publication date: 2008

Host publication information
Title of host publication: Proceedings of the SRA Annual Meeting : Risk Analysis: The science and the Art
Place of publication: McLean, VA
Publisher: Society for Risk Analysis
Source: orbit
Source-ID: 236826
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2008

Late lessons from early warnings for nanotechnology

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Hansen, S. F., Maynard, A., Baun, A., Tickner, J.
Pages: 444-447
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Nature Nanotechnology
Volume: 3
Issue number: 8
ISSN (Print): 1748-3387
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 25.47 SJR 20.612 SNIP 8.171
Web of Science (2017): Impact factor 37.49
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 21.85 SJR 18.916 SNIP 7.649
Nanomaterialer i miljøet - hvor lille er risikoen?

General information
State: Published
Organisations: Urban Water Engineering, Department of Environmental Engineering, Environmental Chemistry, Innovation and Sustainability, Department of Management Engineering
Contributors: Baun, A., Hansen, S. F., Hartmann, N. I. B., Olsen, S. I.
Pages: 127-137
Publication date: 2008

Host publication information
Title of host publication: Vintermøde om jord- og grundvandsforurening, Vingstedcentret 4.-5. marts 2008
Volume: Bind 2
Place of publication: Kgs. Lyngby
Publisher: ATV Jord og Grundvand
Source: orbit
Nanomaterialer - muligheder og risici

General information
State: Published
Organisations: Urban Water Engineering, Department of Environmental Engineering, Environmental Chemistry, Innovation and Sustainability, Department of Management Engineering, National Food Institute
Contributors: Baun, A., Hansen, S. F., Hartmann, N. I. B., Olsen, S. I., Binderup, M., Lam, H. R.
Pages: 195-221
Publication date: 2008

Host publication information
Title of host publication: Nanoteknologiske horisonter
Volume: Kapitel 13
Place of publication: Kgs. Lyngby
Publisher: NanoDTU, Danmarks Tekniske Universitet
Electronic versions:
ENV2008-100.pdf
URLs:
http://www.nano.dtu.dk/upload/centre/nanodtu/nanoteknologiske_horisonter/forside/nanoteknologiske%20horisonter_010808_rettet.pdf
Source: orbit
Source-ID: 221249
Research output: Education › Book chapter – Annual report year: 2008

Options for state chemicals policy reform: A resource guide

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Publication date: 2008

Publication information
Place of publication: Lowell, MA
Publisher: The Lowell Center for Sustainable Production, University of Massachusetts Lowell
Original language: English
Electronic versions:
ENV2008-040.pdf
Source: orbit
Source-ID: 211507
Research output: Education › Book chapter – Annual report year: 2008

Putting risk-risk tradeoffs in perspective: a response to Graham and Wiener

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Hansen, S. F., Tickner, J.
Pages: 475-483
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Journal of Risk Research
Volume: 11
Issue number: 4
ISSN (Print): 1366-9877
Ratings:
BFI (2019): BFI-level 1
Uncertainty and sensitivity analysis of environmental and health risks of nanomaterials

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Grieger, K. D., Hansen, S. F., Baun, A.
Number of pages: 78
Publication date: 2008
Peer-reviewed: Yes
Source: orbit
Source-ID: 221899
Research output: Research - peer-review › Journal article – Annual report year: 2008

Scientific uncertainty about the environmental, health and safety issues (EHS) of nanomaterials has been recognized by scientists, regulators, NGO’s as well as industry as a possible barrier towards nanotechnology reaching its full potential. Historically, research efforts tend to be directed towards specific, narrow scientific research questions with very limited perspective of reducing the overall uncertainty in the short-term, and hence they have had a limited prospect of facilitating informed risk-reducing decision-making processes. While it is important to investigate identified gaps within EHS knowledge and research for the sake of science itself, it is also crucial that these research efforts are strategically focused and prioritized in order to assist regulators, industry, as well as scientists in the EHS challenges that face them in developing nanomaterials. Therefore, this study investigates the main areas of uncertainty related to EHS of nanomaterials, as well as investigates the level, nature and sensitivity of the scientific uncertainty. In this study the scientific uncertainty was systematically mapped by locating the areas of uncertainty through an in-depth analysis of government reports, scientific reviews and primary articles dealing with and/or investigating the potential risks of nanomaterials. Once the locations of uncertainty were identified, we assigned and discussed the level and the sensitivity of the uncertainty. We found that significant knowledge gaps exist not only in terms of documenting potential (eco)toxicological effects, but also in terms of characterizing exposure and nanoparticles behaviour even in simple test systems. For example, uncertainty related to testing strategies and environmentally-realistic exposure scenarios, impedes a successful risk characterisation of engineered nanoparticles according to several reports. This includes establishing, developing and standardising reference materials, monitoring and detection equipment and estimating human and environmental exposure concentrations. These issues ultimately lead to significant challenges in performing human and environmental risk assessments and present a daunting task for regulators. We recommend that increased efforts are made by risk assessors and regulators to recognize the location of EHS uncertainties and to address the sensitivity of identified knowledge gaps while simultaneously ensuring that the “right” scientific questions are addressed. This is a prerequisite to effectively prioritise research resources to reduce uncertainty most pertinent to an accelerated risk analysis of nanomaterials.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Grieger, K. D., Hansen, S. F., Baun, A.
Number of pages: 1
Publication date: 2008
Categories of nanomaterials and their environmental hazards

General information
State: Published
Organisations: Department of Environmental Engineering, Innovation and Sustainability, Department of Management Engineering, Department of Physics
Number of pages: 130
Publication date: 2007

Host publication information
Title of host publication: NANOMAT conference 2007 and the satellite meetings, Bergen 4-9 June 2007 : Abstract Book
Place of publication: Oslo
Publisher: The Research Council of Norway
Source: orbit
Source-ID: 201430
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2007

Categorization framework to aid hazard identification of nanomaterials
The physical, chemical and biological properties of various nanomaterials differ substantially - as do the potential risks they pose. We argue that nanomaterials must be categorized based on the location of the nanoscale structure in the system/material before their hazards can be assessed and propose a categorization framework that enables scientists and regulators to identify the categories of nanomaterials systematically. The framework is applied to a suggested hazard identification approach aimed at identifying causality between inherent physical and chemical properties and observed adverse effects reported in the literature. We tested the workability of the proposed procedure using nanoparticles as an illustrative case study. A database was generated noting the reported inherent physical and chemical properties of the nanoparticles tested and the main effects observed. 428 studies were noted in the database reporting on a total of 965 nanoparticles. We found that although a limited number of studies have been reported on ecotoxicity, more than 120 and 270 have been reported on mammalian toxicity and cytotoxicity, respectively. In general there was a lack of characterization of the nanoparticles studied and it was not possible to link specific properties of nanoparticles to the observed effects. Our study shows that future research strategies must have a strong focus on characterization of the nanoparticles tested.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Theoretical Atomic-scale Physics, Department of Physics, Innovation and Sustainability, Department of Management Engineering
Contributors: Hansen, S. F., Larsen, B. H., Olsen, S. I., Baun, A.
Pages: 243-250
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Nanotoxicology
Volume: 1
ISSN (Print): 1743-5390
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 5.99
Web of Science (2017): Impact factor 5.811
Categorizing Mistaken False Positives in Regulation of Human and Environmental Health

One of the concerns often voiced by critics of the precautionary principle is that a widespread regulatory application of the principle will lead to a large number of false positives (i.e., over-regulation of minor risks and regulation of non-existing risks). The present article proposes a general definition of a regulatory false positive, and seeks to identify case studies that can be considered authentic regulatory false positives. Through a comprehensive review of the science policy literature for proclaimed false positives and interviews with authorities on regulation and the precautionary principle we identified 88 cases. Following a detailed analysis of these cases, we found that few of the cases mentioned in the literature can be considered to be authentic false positives. As a result, we have developed a number of different categories for these cases of "mistaken false positives," including: real risks, "The jury is still out," nonregulated proclaimed risks, "Too narrow a definition of risk," and risk-risk tradeoffs. These categories are defined and examples are presented in order to illustrate their key characteristics. On the basis of our analysis, we were able to identify only four cases that could be defined as regulatory false positives in the light of today's knowledge and recognized uncertainty: the Southern Corn Leaf Blight, the Swine Flu, Saccharin, and Food Irradiation in relation to consumer health. We conclude that concerns about false positives do not represent a reasonable argument against future application of the precautionary principle.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Pages: 255-269
Chemicals regulation and precaution: does REACH really incorporate the precautionary principle

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Hansen, S. F., Carlsen, L., Tickner, J.
Pages: 395-404
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Environmental Science & Policy
Volume: 10
ISSN (Print): 1462-9011
Ratings:
BFI (2019): BFI-level 2
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.31 SJR 1.661 SNIP 1.711
Web of Science (2017): Impact factor 3.826
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.9 SJR 1.677 SNIP 1.581
Web of Science (2016): Impact factor 3.751
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.83 SJR 1.613 SNIP 1.467
Web of Science (2015): Impact factor 2.972
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.02 SJR 1.812 SNIP 1.814
Web of Science (2014): Impact factor 3.018
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.08 SJR 1.687 SNIP 1.957
Web of Science (2013): Impact factor 3.514
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.35 SJR 1.505 SNIP 1.647
Web of Science (2012): Impact factor 2.978
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.06 SJR 1.3 SNIP 1.632
Limits and prospects of the "incremental approach" and the European legislation on the management of risks related to nanomaterials

Scientific uncertainty involved in evaluating potentially harmful properties of engineered nanoparticles complicates and hampers the implementation of proportionate regulative measures by legislators. The European Commission has adopted a so-called "incremental approach", which focuses on adapting existing laws to regulate nanotechnologies, and therefore this paper aims to test the effectiveness of the "incremental approach". Three commercially available products containing fullerenes (C60 and carbon nanotubes) were analysed in a life cycle perspective in order to (1) map current applicable regulations, (2) analyse their applicability to nanomaterials, (3) identify their gaps, and (4) suggest proper solutions. After mapping the life cycle of the three products, we analysed applicable regulations in the order in which they became relevant in their life cycle, i.e.: • The Safety at Workplace Directives, • Directive 61/1996 on the Integrated Pollution Prevention and Control, • The European Union's Directive on the Registration, Evaluation, Authorization and Restriction of Chemicals, and • The Waste Management Directives. It was found that the applicability of environmental laws is limited due to difficulties in generating sufficient data on the nanomaterials residing in the products according to their life cycles.
Further, metrology tools are unavailable; thresholds are not tailored to the nanoscale; and toxicological data and occupational exposure limits cannot be established with existing methodologies. We conclude that the “incremental approach” can only be applicable with the implementation of due amendments.

**General information**
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Quantitative Sustainability Assessment, Department of Management Engineering, Center for Nanoteknologi, University of Padova
Contributors: Franco, A., Hansen, S. F., Olsen, S. I., Butti, L.
Pages: 171-183
Publication date: 2007
Peer-reviewed: Yes

**Publication information**
Journal: Regulatory Toxicology and Pharmacology
Volume: 48
Issue number: 2
ISSN (Print): 0273-2300
Ratings:
BFI (2019): BFI-level 1
Web of Science (2019): Indexed yes
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.92 SJR 0.812 SNIP 1.005
Web of Science (2017): Impact factor 2.815
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.15 SJR 0.724 SNIP 0.92
Web of Science (2016): Impact factor 2.221
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.25 SJR 0.734 SNIP 1.01
Web of Science (2015): Impact factor 2.227
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.13 SJR 0.75 SNIP 1.089
Web of Science (2014): Impact factor 2.031
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.46 SJR 0.83 SNIP 1.085
Web of Science (2013): Impact factor 2.142
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.38 SJR 0.81 SNIP 1.135
Web of Science (2012): Impact factor 2.132
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.23 SJR 0.865 SNIP 1.113
Web of Science (2011): Impact factor 2.427
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.926 SNIP 1.193
Web of Science (2010): Impact factor 2.162
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Limits and prospects of the "incremental approach" and the European legislation on the management of risks related to nanomaterials

General information
State: Published
Organisations: Department of Environmental Engineering, Innovation and Sustainability, Department of Management Engineering
Contributors: Franco, A., Hansen, S. F., Olsen, S. I., Butti, L.
Number of pages: 1
Pages: 77-77
Publication date: 2007

Host publication information
Title of host publication: Nanotoxicology Conference, San Servolo Servizi, Venice, Italy, 19-21 April 2007: Abstract Book
Place of publication: London, UK
Publisher: Informa Healthcare
Source: orbit
Source-ID: 202893
Research output: Research - peer-review > Conference abstract in proceedings – Annual report year: 2007

Nanomaterials in consumer products and potential hazards

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Hansen, S. F., Baun, A.
Pages: 59-60
Publication date: 2007

Host publication information
Title of host publication: Nanotoxicology Conference, San Servolo Servizi, Venice, Italy, 19-21 April 2007
Volume: Abstract book
Place of publication: London, UK
Publisher: Informa Healthcare
Source: orbit
Source-ID: 202890
Research output: Research - peer-review > Conference abstract in proceedings – Annual report year: 2007
Nanotechnology/Health effects of nanoparticles

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Fate & Effect of Chemicals, Innovation and Sustainability, Department of Management Engineering, Lab-on-a-Chip, Department of Micro- and Nanotechnology
Contributors: Hansen, S. F., Rasmussen, R., Sørensen, S., Baun, A., Olsen, S. I., Mølhave, K.
Publication date: 2007

Host publication information
Title of host publication: Nanotechnology
Publisher: Wikibooks
Editor: Mølhave, K.
URLs:
Source: orbit
Source-ID: 208308
Research output: Research › Book chapter – Annual report year: 2007

Nanoteknologi - er det farligt?

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Baun, A., Hansen, S. F.
Pages: 14-15
Publication date: 2007
Peer-reviewed: No

Publication information
Journal: Ingeniøren
Issue number: 14. december 1. sektion
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Source: orbit
Source-ID: 208816
Research output: Research › Journal article – Annual report year: 2007

Response to "Regulatory false positives: True, false or uncertain?"

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Pages: 1087-1089
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Risk Analysis
Volume: 27
Original language: English
Source: orbit
Source-ID: 207567
Research output: Research › peer-review › Journal article – Annual report year: 2007

Survey of nanotechnological consumer products

General information
State: Published
The challenges of adopting voluntary health, safety and environment measures for manufactured nanomaterials: Lessons from the past for more effective adoption in the future

This article explores the use of voluntary environmental programs in the United States in the past, and applies the lessons learned from these experiences to the regulation of nanomaterials. The authors found that the key elements of any voluntary environmental program should be incentives to participate for various stakeholders, agency guidance and technical assistance, and transparency both in design, reporting and evaluation. The authors also recommend that any voluntary program become mandatory after 3 no more than three years to motivate voluntary participation.

Categorizing commercially available nanoproducts in a risk management perspective
Environmental risk assessment of nanotechnology: categories of nanomaterials: WE1/MI/1

General information
State: Published
Organisations: Department of Environmental Engineering, Department of Physics, Innovation and Sustainability, Department of Management Engineering
Number of pages: 48
Publication date: 2006

Host publication information
Title of host publication: Proceedings of the Environmental effects of nanoparticles and nanomaterials, 18-19 September 2006, London
Place of publication: London, UK
Publisher: SETAC-UK
Source-ID: 195928
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2006

Mapping the gaps in regulation of nanotechnology in a life cycle perspective

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Franco, A., Hansen, S. F., Olsen, S., Baun, A., Butti, L.
Number of pages: 29
Publication date: 2006

Host publication information
Title of host publication: Controversies and solutions in environmental sciences : SETAC Europe 16th annual meeting, The Hague, The Netherlands, 7-11 May 2006
Volume: Abstracts
Place of publication: Brussels
Publisher: SETAC
Source-ID: 189224
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2006

Risk management, risk-risk tradeoffs and the precautionary principle

General information
State: Published
Organisations: Department of Environmental Engineering
Publication date: 2005

Host publication information
Title of host publication: Environmental effects of nanoparticles and nanomaterials, 18-19 September 2006, London
Place of publication: London, UK
Publisher: SETAC-UK
Source-ID: 195927
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2006

Risk management, risk-risk tradeoffs and the precautionary principle

General information
State: Published
Organisations: Department of Environmental Engineering
Publication date: 2005

Host publication information
Title of host publication: SETAC 26th Annual Meeting in North America, 13-17 November 2005, Baltimore, Maryland, USA : Environmental Science in a Global Society: SETAC's Role in the Next 25 Years
Place of publication: Lawrence, KS
Publisher: Allen Press
Source: orbit
State-of-the-art critical review of the potential hazards of manufactured nanomaterials

General information
State: Published
Organisations: Department of Environmental Engineering
Publication date: 2005

Host publication information
Title of host publication: SETAC 26th Annual Meeting in North America, 13-17 November 2005, Baltimore, Maryland, USA: Environmental Science in a Global Society: SETAC's Role in the Next 25 Years
Place of publication: Lawrence, KS
Publisher: Allen Press
Source: orbit
Source-ID: 189859
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2005

Projects:

Shale gas in a Danish context
Hansen, S. F., Project Participant, Department of Environmental Engineering, Environmental Chemistry
31/08/2015 → 29/01/2016
Keywords: Shale gas, Risk screening
Project: Research

NanoWASTE: Investigating the fate of nanomaterials in waste water treatment plants; removal, release and subsequent impacts
Hansen, S. F., Project Participant, Department of Environmental Engineering, Environmental Chemistry
Polesel, F., Project Participant, Department of Environmental Engineering, Environmental Chemistry
01/12/2014 → 30/05/2018
Keywords: Nanoparticles, Wastewater treatment
Collaborators: Norwegian Research Council
Project: Research

Microplastics Occurrence, effects and sources of releases to the environment in Denmark
Microplastics Occurrence, effects and sources of releases to the environment in Denmark Environmental project No. 1793, 2015. Ministry of Environment and Food The Danish Environmental Protection Agency.
Hansen, S. F., Project Participant, Department of Environmental Engineering, Environmental Chemistry
01/01/2015 → 12/11/2015
Keywords: Microplastics
Collaborators: COWI AS
Documents:
Lassen et al. 2015
Project: Research

Support for 3rd regulatory review of nanomaterials – environmental legislation
Ricardo Energy & Environment, in partnership with subcontractors Milieu Consulting and the Technical University of Denmark (DTU), was commissioned by the European Commission to carry out a project entitled “The preparation of the third regulatory review on nanomaterials - environmental legislation”, specific contract number 070201/ENV/2015/SI2.716613/ENV.A3, Commission reference ENV.C.3/ETU/2015/0030. The study objective was to compile and develop information on nanomaterials and advanced materials in the environment and explore further the regulatory implementation challenges. The study had three main components: - A preliminary evaluation of releases of nanomaterials to different media (air, water, land, recycling and waste disposal). - A review of progress on the application of environmental and other key legislation to nanomaterials. - A prospective view on future developments in advanced materials, and challenges for environmental legislation. Consultation with stakeholders was carried out by email and telephone, and a stakeholder workshop was held on 21 June 2016. At the workshop, the interim findings were presented, and stakeholder feedback and views were discussed. Following the workshop, stakeholders provided feedback in writing. This feedback has been taken into account for the finalisation of the report.
Hansen, S. F., Project Participant, Department of Environmental Engineering, Environmental Chemistry
09/11/2015 → 09/09/2016
Collaborators: Milieu Ltd., Richardo Energy & Environment
Documents:
Broomfield et al. 2016
Project: Research

Drivers and Barriers to the Innovation and Implementation of Alternative Solutions to Climate Adaption
Madsen, H. M., PhD Student, Department of Environmental Engineering
Mikkelsen, P. S., Main Supervisor, Department of Environmental Engineering
Andersen, M. M., Supervisor, Department of Management Engineering
Rygaard, M., Supervisor, Department of Environmental Engineering
Hansen, S. F., Examiner, Department of Environmental Engineering
Larsen, L. O., Examiner, Department of Geology and Geotechnical Engineering
Truffer, B., Examiner
Institut stipendie (DTU)
15/12/2014 → 11/12/2018
Award relations: Drivers and Barriers to the Innovation and Implementation of Alternative Solutions to Climate Adaption
Project: PhD

Characterization and Management of Nanowaste
Heggelund, L. R., PhD Student, Department of Environmental Engineering
Boldrin, A., Main Supervisor, Department of Environmental Engineering
Astrup, T. F., Supervisor, Department of Environmental Engineering
Hansen, S. F., Supervisor, Department of Environmental Engineering
Kjeldsen, P., Examiner, Department of Environmental Engineering
Ingerslev, F., Examiner
Mitrano, D. M., Examiner
Samfinansieret - Andet
15/01/2014 → 30/09/2017
Award relations: Characterization and Management of Nanowaste
Project: PhD

New high-quality mined nanomaterials mass produced for plastic and wood-plastic nanocomposites
Miseljic, M., PhD Student, Department of Management Engineering
Olsen, S. I., Main Supervisor, Department of Management Engineering
Hauschild, M. Z., Supervisor, Department of Management Engineering
Birkved, M., Examiner, Department of Management Engineering
Hansen, S. F., Examiner
Hischier, R., Examiner
Institut, samfinansiering
01/01/2011 → 19/03/2015
Award relations: New high-quality mined nanomaterials mass produced for plastic and wood-plastic nanocomposites
Project: PhD

Life cycle assessment applied to nanomaterials in solid waste management - Focus on human health impact assessment
Laurent, A., PhD Student, Department of Management Engineering
Hauschild, M. Z., Main Supervisor, Department of Management Engineering
Hellweg, S., Supervisor
Birkved, M., Examiner, Department of Management Engineering
Hansen, S. F., Examiner, Department of Environmental Engineering
Walser, T., Examiner
Walser, T., Examiner
1/3 DTU-stip, 2/3 FUR/andet
01/05/2010 → 24/03/2014
Award relations: Life cycle assessment applied to nanomaterials in solid waste management - Focus on human health impact assessment
Project: PhD

Nanotechnology, Innovation and the Precautionary Principle
Hansen, S. F., PhD Student, Department of Environmental Engineering
Baun, A., Main Supervisor, Department of Environmental Engineering
Aquatic toxicity testing for hazard identification of engineered nanoparticles
Sørensen, S. N., PhD Student, Department of Environmental Engineering
Baua, A., Main Supervisor, Department of Environmental Engineering
Hansen, S. F., Supervisor, Department of Environmental Engineering
Lützheft, H. H., Supervisor
Mayer, P., Examiner, Department of Environmental Engineering
Kühnel, D., Examiner
Palmqvist, A., Examiner
Institut stipendie (DTU) Samf.
01/04/2012 → 30/06/2016
Award relations: Aquatic toxicity testing for hazard identification of engineered nanoparticles
Project: PhD

Environmental Effects and Risk Evaluation of Engineered Nanoparticles - Ecotoxicity
Skjolding, L. M., PhD Student, Department of Environmental Engineering
Baua, A., Main Supervisor, Department of Environmental Engineering
Selck, H., Supervisor
Hansen, S. F., Examiner, Department of Environmental Engineering
Banta, G. T., Examiner
Banta, G. T., Examiner
Institut stipendie (DTU) Samf.
01/09/2012 → 15/12/2015
Award relations: Environmental Effects and Risk Evaluation of Engineered Nanoparticles - Ecotoxicity
Project: PhD

Release of nanoparticles from consumer products
Mackevica, A., PhD Student, Department of Environmental Engineering
Hansen, S. F., Main Supervisor, Department of Environmental Engineering
Olsson, M. E., Supervisor, Department of Environmental Engineering
Löschner, K., Examiner, National Food Institute
Cornelis, G., Examiner
Jensen, K. A., Examiner
Cornelis, G., Examiner
Alstrup Jensen, K., Examiner
Samfinansieret - Andet
01/10/2013 → 01/12/2016
Award relations: Release of nanoparticles from consumer products
Project: PhD

Ecotoxicity and groundwater remediation potential of engineered nanoparticles
Hjorth, R., PhD Student, Department of Environmental Engineering
Baua, A., Main Supervisor, Department of Environmental Engineering
Broholm, M. M., Supervisor, Department of Environmental Engineering
Hansen, S. F., Supervisor, Department of Environmental Engineering
Rygaard, M., Examiner, Department of Environmental Engineering
Malloy, T. F., Examiner
Syberg, K., Examiner
Samfinansieret - Andet
15/11/2013 → 08/02/2017
Award relations: Ecotoxicity and groundwater remediation potential of engineered nanoparticles
Project: PhD

Qualitative and Quantitative Methods for Evaluation of Human Exposure to Nanomaterials
Liguori, B., PhD Student, Department of Environmental Engineering
**Waste material recycling: Assessement of contaminants limiting recycling**

Pivnenko, K., PhD Student, Department of Environmental Engineering
Astrup, T. F., Main Supervisor, Department of Environmental Engineering
Eriksson, E., Supervisor, Department of Environmental Science and Engineering
Hansen, S. F., Examiner, Department of Environmental Engineering
Dornack, C., Examiner
Riber, C., Examiner, Department of Environmental Engineering
Dornack, C., Examiner

1/3 DTU-stip, 2/3 FUR/andet
15/08/2012 → 01/09/2016

Award relations: Waste material recycling: Assessement of contaminants limiting recycling
Project: PhD

**NanoDen: NanoDen: Nanomaterial - Occurence and effects in the Danish Environment**

The overall objective of the project is to provide answers to whether nanomaterials might cause a risk to the Danish environment, and if so under which conditions. Further the project will generate some new knowledge in relation to the fate of nanomaterials in the environment, knowledge generated with the aim of improving the exposure estimations in the project. The project will aim at answering the questions related to emissions, environmental fate, exposure/concentrations, effects and risks of nanomaterials in the Danish environment with the aim of eventually providing answers in relation to the overall objective. This will include an eventual summarising presentation and discussion in sub-project 6 of assumptions and uncertainties, including methodological issues encountered throughout the project. The focus in the project will be on translating existing knowledge into the best possible estimations of risks of nanomaterials within the scope of the project.

Baun, A., Project Participant, Department of Environmental Engineering, Environmental Chemistry
Lützhøft, H. H., Project Participant, Department of Environmental Engineering, Environmental Chemistry
Hartmann, N. B., Project Participant, Department of Environmental Engineering, Environmental Chemistry
Hansen, S. F., Project Participant, Department of Environmental Engineering

01/01/2013 → 01/07/2015

Project: Research

**MARINA: Managing Risks of NanoMATERIALs**

MARINA will address the four central themes: Materials, Exposure, Hazard, and Risk and develop beyond-state-of-the-art referential tools and integrate them for both human health and environment.

Baun, A., Project Manager, Department of Environmental Engineering
Hansen, S. F., Project Participant, Department of Environmental Engineering
Hartmann, N. B., Project Participant, Department of Environmental Engineering

Project ID: 30860

Ukendt: DKK2,115,000.00
01/03/2011 → 28/02/2015

Award relations: Managing Risks of NanoMATERIALs
Project: Research

**Rural-Foreign: Investigation of the potential risk posed to drinking water by man-made nanoparticles. Department of Environment, Rules and Foreign Affairs**

Identify those uses likely to result in man-made nanoparticles reaching water sources and obtain estimates of quantities used, task 2

Hansen, S. F., Project Manager, Department of Environmental Engineering

Project ID: 30755

Ukendt: DKK45,000.00
15/09/2009 → 31/12/2009

Award relations: Investigation of the potential risk posed to drinking water by man-made nanoparticles. Department of Environment, Rules and Foreign Affairs
**NanoRiskClass: NanoRiskClass **** - et nyt risikoklassifikations system for nanomaterialer**


Baun, A., Project Manager, Department of Environmental Engineering
Hansen, S. F., Project Participant, Department of Environmental Engineering

Project ID: 30790
Ukendt: DKK350,000.00
01/01/2010 → 01/07/2010
Award relations: NanoRiskClass **** - et nyt risikoklassifikations system for nanomaterialer
Project: Research

**QSAR-NP: Development of (Quantitative Structure-Activity Relationships models for nanoparticles**

The purpose of this project is to develop Quantitative Structure-Activity Relationships-models for engineered nanoparticles (QSARNP) that can predict the human health and environmental effect based on inherent physico-chemical properties of nanoparticles. Based on the hypothesis that the biological effects of engineered nanoparticles are directly linked to the inherent physico-chemical properties, the aim of this project is to provide guidance to companies, material developers, and regulators to screen and rank engineered nanoparticles according to their toxicity. Within a two-year period, we will carry out research dedicated to the following objectives: To identify and select appropriate human health and environmental toxicological endpoints and nanoparticle characteristics to be used as hazard descriptors To develop and validate model(s) for estimation of the (eco)toxicity of engineered nanoparticles based on existing knowledge on physico-chemical properties and hazards documented in laboratory studies

Baun, A., Project Participant, Department of Environmental Engineering
Kusk, K. O., Project Participant, Department of Environmental Engineering
Hansen, S. F., Project Participant, Department of Environmental Engineering

Ukendt: DKK0.00
01/01/2009 → 31/12/2011
Award relations: Development of (Quantitative Structure-Activity Relationships models for nanoparticles
Project: Research

**Activities:**

**A comparative analysis of teaching methods for large classes**

**Period:** 20 Sep 2018

Lauge Peter Westergaard Clausen (Guest lecturer)
Redante Mendoza (Other)
Jason Bazylak (Other)
Mikael Rørdam Andersen (Guest lecturer)
Steffen Foss Hansen (Guest lecturer)

Department of Environmental Engineering

Environmental Fate & Effect of Chemicals

Section for Synthetic Biology

Network Engineering of Eukaryotic Cell factories

Department of Biotechnology and Biomedicine

**Related event**

*The European Society for Engineering Education 2018*

18/09/2018 → 21/09/2018
2800 Kgs Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

**DTU Sustain 2017**
*Period: 6 Dec 2017*
Steffen Foss Hansen (Organizer)
Kristian Mølhave (Organizer)
Department of Environmental Engineering
Environmental Chemistry
Department of Micro- and Nanotechnology
Molecular Windows

**Description**
Steering group member of DTU Sustain 2017
Degree of recognition: National

**Links:**
http://www.sustain.dtu.dk (Conference website)

**Related event**
**DTU Sustain 2017**
*06/12/2017 → 06/12/2017*
Kgs. Lyngby, Denmark
Activity: Attending an event › Participating in or organising a conference

**A Critical and in-depth analysis of the environmental aspect of the OECD SP dossiers**
*Period: 1 Jun 2017*
Steffen Foss Hansen (Speaker)
Anders Baun (Other)
Rune Hjorth (Other)
Lars Michael Skjolding (Other)
Department of Environmental Engineering
Environmental Chemistry

**Description**
Oral presentation at the 8th International Symposium on Nanotechnology, Occupational and Environmental Health.
Elsinore. 29 May-1 June, 2017.
Degree of recognition: International

**Related external organisation**
**National Research Centre for the Working Environment**
Lersø Parkallé 105, 2100 København Ø, Denmark
Activity: Talks and presentations › Conference presentations

**2017 GEMS Spring Meeting**
*Period: 2 May 2017*
Steffen Foss Hansen (Participant)
Department of Environmental Engineering
Environmental Chemistry
Degree of recognition: International
Documents:
Nanomaterial consumer products in a consolidated database wb comments

**Related event**
**2017 GEMS Spring Meeting: Nanomaterials and Consumer Product Safety**
Nanoworld Conference
Period: 4 Apr 2017
Steffen Foss Hansen (Chairman)
Department of Environmental Engineering
Environmental Chemistry

Related event

Nanoworld Conference
03/04/2017 → 05/04/2017
Newton, United States
Activity: Attending an event › Participating in or organising a conference

Nanoworld Conference
Period: 4 Apr 2017
Steffen Foss Hansen (Speaker)
Department of Environmental Engineering
Environmental Chemistry
Links:

Related event

Nanoworld Conference
03/04/2017 → 05/04/2017
Newton, United States
Activity: Talks and presentations › Conference presentations

Member of Panel on Work Environment at DTU Environment (External organisation)
Period: 1 Apr 2017
Steffen Foss Hansen (Participant)
Department of Environmental Engineering
Environmental Chemistry

Description
Member of Panel on Work Environment at DTU Environment
Degree of recognition: Local

Related external organisation

Member of Panel on Work Environment at DTU Environment
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

SRA Policy Forum: Risk Governance for Key Enabling Technologies
Period: 2 Mar 2017
Steffen Foss Hansen (Organizer)
Department of Environmental Engineering
Environmental Chemistry

Description
Chairman. Synthetic Biology Applications and State of Science. Risk Governance of Key Emerging Technologies. Venice, Italy, 1-3 March 2017
Degree of recognition: International
Related event

SRA Policy Forum: Risk Governance for Key Enabling Technologies
01/03/2017 → 03/03/2017
Venice, Italy
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Uvildige Ekspertpanel Deponering af radioaktivt affald i DK (External organisation)
Period: 2017 → …
Steffen Foss Hansen (Chairman)
Department of Environmental Engineering
Environmental Chemistry

Description
Member of the independent expert panel on deposit of radioactive waste in Denmark
Degree of recognition: National
Links:
http://ufm.dk/aktuelt/temaer/deponering-af-radioaktivt-affald-i-dk/det-uvildige-ekspertpanel-1/det-uvildige-ekspertpanel#cookieoptin

Related external organisation

Uvildige Ekspertpanel Deponering af radioaktivt affald i DK
Udannelser- og Forskningsministeriet, Børsgade 4, 2135, København K, Denmark
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

DTU Sustain 2016
Period: 30 Nov 2016
Steffen Foss Hansen (Organizer)
Kristian Mølhave (Organizer)
Department of Environmental Engineering
Environmental Chemistry
Department of Micro- and Nanotechnology
Molecular Windows
Documents:
SustainAbstracts2016-20161130-1
Links:
http://www.sustain.dtu.dk/

Related event

DTU Sustain 2016
30/11/2016 → …
Activity: Attending an event › Participating in or organising a conference

Chemical Processes and Materials (Journal)
Period: 2016 → …
Steffen Foss Hansen (Reviewer)
Department of Environmental Engineering
Environmental Chemistry

Description
Associate Editor
Degree of recognition: International
Links:
http://chempm.org/ (Homepage of Chemical Processes and Materials)
Related journal

**Chemical Processes and Materials**
Local database
Activity: Research › Journal editor

**Continuing education coordinator at DTU Environment**
Period: 2016 → …
Steffen Foss Hansen (Lecturer)
Department of Environmental Engineering
Environmental Chemistry
Degree of recognition: Local
Links:
http://www.env.dtu.dk/english/Teaching/Continuing-Education (DTU Environment's Continuing education website )
Activity: Other

**NanolImpact (Journal)**
Period: 2016 → …
Steffen Foss Hansen (Reviewer)
Department of Environmental Engineering
Environmental Chemistry

**Description**
Associate Editor
Degree of recognition: International
Links:
https://www.journals.elsevier.com/nanoimpact (Homepage of NanolImpact)

Related journal

**NanolImpact**
2452-0748
Scopus rating (2017): CiteScore 3.61 SJR 0.872 SNIP 0.634, Web of Science (2019): Indexed yes
Central database
Activity: Research › Journal editor

**Pedagogical teaching coordinator at DTU Environment**
Period: 2016 → …
Steffen Foss Hansen (Other)
Department of Environmental Engineering
Environmental Chemistry
Degree of recognition: Local
Activity: Other

**Steering group member of the project "Plastfri Roskilde Fjord" (Event)**
Period: 2016 → 2018
Steffen Foss Hansen (Chairman)
Department of Environmental Engineering
Environmental Chemistry
Degree of recognition: National
Links:
http://plasticchange.dk/vores-loesninger/plastfri-roskilde-fjord/

Related event

**Steering group member of the project "Plastfri Roskilde Fjord"**
DTU Sustain 2015  
Period: 17 Dec 2015  
Steffen Foss Hansen (Organizer)  
Department of Environmental Engineering  
Environmental Chemistry  
Documents:  
sustain2015abstracts  
Links:  
http://www.sustain.dtu.dk/  

Related event  
DTU Sustain 2015  
17/12/2015 → …  
Activity: Attending an event › Participating in or organising a conference  

International Congress on Education, Innovation and Learning Technologies  
Period: 21 Sep 2015 → 23 Sep 2015  
Steffen Foss Hansen (Participant)  
Department of Environmental Engineering  
Environmental Chemistry  
Description  
Oral presentation on New rooms for blended learning  
Documents:  
programa provisional ICEILT2015  

Related event  
International Congress on Education, Innovation and Learning Technologies  
21/09/2015 → 23/09/2015  
Granada, Spain, Spain  
Activity: Attending an event › Participating in or organising a conference  

International Congress on Education, Innovation and Learning Technologies  
Period: 21 Sep 2015 → 23 Sep 2015  
Steffen Foss Hansen (Speaker)  
Department of Environmental Engineering  
Environmental Chemistry  
Documents:  
01-09-2015 Hansen and Clausen 2015 Educating Future Environmental Engineers - Granada - SFH  

Related event  
International Congress on Education, Innovation and Learning Technologies  
21/09/2015 → 23/09/2015  
Granada, Spain, Spain  
Activity: Talks and presentations › Conference presentations  

Health Risks, Precaution and Innovation  
Period: 24 Jun 2015  
Steffen Foss Hansen (Speaker)  
Department of Environmental Engineering
Environmental Chemistry

Documents:
ANSES 2015

Related event

Health Risks, Precaution and Innovation
24/06/2015 → 24/06/2015
Paris, France
Activity: Talks and presentations › Conference presentations

Member of the Environmental, health and safety network at the Technical University of Denmark (Event)
Period: 2015 → …
Steffen Foss Hansen (Chairman)
Department of Environmental Engineering
Environmental Chemistry
Degree of recognition: Local

Related event

Member of the Environmental, health and safety network at the Technical University of Denmark
05/01/2015 → …
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Examiner, Environmental Regulation and History, International Master of Science in Environmental Risk, Roskilde University
Period: 2014 → …
Steffen Foss Hansen (External examiner)
Department of Environmental Engineering
Environmental Chemistry
Degree of recognition: Regional
Activity: Examinations and supervision › External examination

Steering group member of the Joint Nanotechnology Project CIEL, ECOS and Öko Institut (External organisation)
Steffen Foss Hansen (Chairman)
Department of Environmental Engineering
Environmental Chemistry
Degree of recognition: International
Links:

Related external organisation

Steering group member of the Joint Nanotechnology Project CIEL, ECOS and Öko Institut
Activity: Membership › Membership of committees, commissions, boards, councils, associations, organisations, or similar

Environmental Health 2013
Period: 6 Mar 2013
Steffen Foss Hansen (Chairman)
Department of Environmental Engineering
Environmental Chemistry

Description
Session on Research
Chair on session on Research
Documents:
Conference programme

Related event

Environmental Health 2013: Science and Policy to Protect Future Generations
03/03/2013 → 06/03/2013
Boston, United States
Activity: Attending an event › Participating in or organising a conference

Environmental Health 2013
Period: 3 Mar 2013 → 6 Mar 2013
Steffen Foss Hansen (Organizer)
Department of Environmental Engineering
Environmental Chemistry

Description
Chairman
Degree of recognition: International

Related event

Environmental Health 2013: Science and Policy to Protect Future Generations
03/03/2013 → 06/03/2013
Boston, United States
Activity: Attending an event › Participating in or organiseing a conference

Research Council Norway (External organisation)
Period: 2013 → 2014
Steffen Foss Hansen (Chairman)
Department of Environmental Engineering
Environmental Chemistry

Description
Assessor of Grant Applications related to NANO2021 Innovationsprosjekter i næringslivet innen nanoteknologi og avanserte materialer
Degree of recognition: International

Related external organisation

The Research Council of Norway
Drammensveien 288 Lysaker, Norway, N-1327, Oslo, Norway
Activity: Membership › Membership in review committee

Nanotechnology and human health
Period: 10 Dec 2012
Steffen Foss Hansen (Invited speaker)
Department of Environmental Engineering
Environmental Chemistry

Description
Exposure pathways

Related event

Nanotechnology and human health: Scientific evidence and risk governance
10/12/2012 → 11/12/2012
Bonn, Germany
Activity: Talks and presentations › Conference presentations
Temamøde: Virker EU's regulering af nanomaterialer i arbejdsmiljøet?
Period: 28 Nov 2012
Steffen Foss Hansen (Invited speaker)
Department of Environmental Engineering
Environmental Chemistry

Description
Er medarbejdere og forbrugere tilstrækkeligt sikret?
Links:

Related event
Temamøde: Virker EU's regulering af nanomaterialer i arbejdsmiljøet?
28/11/2012 → 28/11/2012
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

Nanosafe 2012
Period: 14 Nov 2012
Steffen Foss Hansen (Speaker)
Department of Environmental Engineering
Environmental Chemistry

Description
In order to understand how companies identify and handle emerging risks related to nanomaterials, we completed more than 15 in-depth interviews with occupational health and safety (OHS) representatives in various Danish organisations. Companies varied not only greatly in regard to number of employees, overall R & D capacity and health and safety personnel, but also in regard to level of which, they already use/produce products that contain nanomaterials. Surprisingly, very little research has been done on how companies become alert to emerging issues although this initial identification of emerging risks is a prerequisite for any subsequent risk management. Key unanswered questions evolve around how companies: 1) Initially identify potentially emerging risks; 2) Collect and analyze data on these risks; 3) how they communicate results of their analysis internally and externally; 4) how they complete their analysis of management options and subsequently implementation of these management options and finally, 5) what the implications of action taken are or has been. Through our interviews we found that the level of awareness about the potential occupational risk associated with nanomaterials varied greatly and range from “having just heard about potential risks and planning to look into it” to “having initiated an internal full risk assessment currently under external peer-review”. Employees noting “that something might not be right” as well as media rumors turned out to be the two main sources of identification of emerging risks, whereas ad hoc personal and non-formal networks and meetings with academics and health care officials also played a role in larger organisations. Various sources were used to obtain more factual information including: Google; Newsletters from the National Research Centre for the Working Environment in Denmark; chemistry databases and scientific articles, but the information gathering process itself was somewhat unsystematic and seems to be completed ad hoc over time. Internal data analysis was performed by occupational health personal within the companies in constant consideration of resources available, priorities, possible management options, etc. unless individual OHS representative “felt like it” putting far more effort into it. Very often independent external experts were consulted in order to learn more and get outside confirmation of key internal findings and interpretations of the available literature. The selection of management options often involved a pro et con analysis of various options considering various technical and operational barriers whereas implementations often followed a process of: 1) Double-checking that company is in compliance with existing legislation and guidelines - often non-NM specific; 2) Initial mapping of NM R & D within the company; 3) Initiation of a capacity building process; 4) Mapping of NM exposure (sometimes very extensive); 5) Mapping of health effects among employees (again sometimes very extensive) and 6) Mapping and implementation of possible management options. Overall, very few options had been implemented about mostly "easy", "low-hanging fruit" - PE-options and administrative controls. Limited or no implementation of more thorough process-related options or engineering controls was identified primarily explained by the continued uncertainty related to health effects of nanomaterials as well as uncertainty about legislation and best practices. Results were mostly communicated internally via intranets or internal workshops with health representatives. Externally communications included publication of scientific papers, posting of information on company websites, but surprisingly involved no or very limited dialogue with authorities. This was considered irrelevant at best and potentially a source of additional confusion and bureaucracy. Overall, implications of action taken within the companies have had little impacts, but in general company representatives noted that they had gotten an improved knowledge about NM risks; that there was a general alertness regarding risks related to airborne NPs
and – in some companies - that there was an increased dialogue between workers and leadership.

Horizon-scanning and Identification of Emerging Risk among Nanotech-companies

Related event

Nanosafe 2012: International Conference on Safe production and use of nanomaterials
13/11/2012 → 15/11/2012
Grenoble, France
Activity: Talks and presentations › Conference presentations

Training on Human Health and Environmental aspects of Nanomaterials
Period: 5 Nov 2012 → 7 Nov 2012
Steffen Foss Hansen (Organizer)
Department of Environmental Engineering
Environmental Chemistry
Description
Organizer, course lecturer, coordinator
Environmental exposure of Nanomaterials

Related event

Training on Human Health and Environmental aspects of Nanomaterials
05/11/2012 → 07/11/2012
Helsinki, Finland
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

SRA Europe 2012
Steffen Foss Hansen (Organizer)
Department of Environmental Engineering
Environmental Chemistry
Description
Chairman
Degree of recognition: International
Links:

Related event

SRA Europe 2012: 21th Annual conference
18/06/2012 → 20/06/2012
Zurich, Switzerland
Activity: Attending an event › Participating in or organising a conference

SRA-Europe 21st Annual Conference
Period: 18 Jun 2012
Steffen Foss Hansen (Chairman)
Department of Environmental Engineering
Environmental Chemistry
Description
New approaches in risk assessment
Documents:
SRA Europe 2012 Book of abstracts

Links:
http://www.sraeurope.org/filehandler.ashx?file=10312

Related event

SRA-Europe 21st Annual Conference
18/06/2012 → 20/06/2012
Zurich, Switzerland
Activity: Attending an event › Participating in or organising a conference

Prizes:

Chemicals in the Environment - Best course of the year 2012/2013 chosen by the students
Steffen Foss Hansen (Recipient)
Department of Environmental Engineering, Environmental Chemistry

Details
Awarded date: 2013
Degree of recognition: Local
Prize: Prizes, scholarships, distinctions

Environmental Management and Ethics - Best course of the year 2004/2005 chosen by the students
Steffen Foss Hansen (Recipient)
Department of Environmental Engineering, Environmental Chemistry

Details
Awarded date: 2005
Degree of recognition: Local
Prize: Prizes, scholarships, distinctions

The Director Gorm-Petersen memorial grant to young scientist in promising development
Steffen Foss Hansen (Recipient)
Department of Environmental Engineering, Environmental Chemistry

Details
Awarded date: 2009
Degree of recognition: National
Granting Organisations: Direktør P. Gorm-Petersens og Hustrus Legat
event: PhD graduation ceremony
Prize: Prizes, scholarships, distinctions

Press clippings:

OECD nanomaterials programme 'of little value' for risk assessment
Steffen Foss Hansen
02/03/2017

Description
Criticism from Ecos, Ciel and Oeko-Institute aimed at industry and EU policy makers
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

OECD nanomaterials programme 'of little value' for risk assessment
02/03/2017
Chemical Watch (International), Web
Andrew Turley
Criticism from Ecos, Ciel and Oeko-Institute aimed at industry and EU policy makers
Steffen Foss Hansen
Five Questions for Steffen Foss Hansen
Steffen Foss Hansen
23/02/2017

Description
A Danish scholar talks about his online database of ‘nano-enhanced’ products — many made with materials that could be hazardous.
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Five Questions for Steffen Foss Hansen
23/02/2017
UNDARK (International), Web
Fabio Turone
https://undark.org/article/five-questions-steffen-foss-hansen/
A Danish scholar talks about his online database of ‘nano-enhanced’ products — many made with materials that could be hazardous.
Steffen Foss Hansen
Press/Media: Press / Media

OECD conclusions about nanomaterials and test guidelines disputed
Steffen Foss Hansen
05/01/2017

Description
Danish, US researchers say further research needed to substantiate suitability claim
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

OECD conclusions about nanomaterials and test guidelines disputed
05/01/2017
Chemical Watch (International), Web
Andrew Turley
Danish, US researchers say further research needed to substantiate suitability claim
Steffen Foss Hansen

Relations
Activities:
A Critical and in-depth analysis of the environmental aspect of the OECD SP dossiers
Press/Media: Press / Media

Hård kritik af Total og kommune
Steffen Foss Hansen
01/12/2016

Description
HØRING: Prøveboring efter skifergas har slidt på kommune og borgere.

Subject
Shale gas extraction and environment
Department of Environmental Engineering, Environmental Chemistry

Media coverage (1)

Hård kritik af Total og kommune
01/12/2016
https://apps-infomedia-dk.proxy.findit.dtu.dk/mediearkiv/link?articles=e601d8de (Regional), Denmark, Print
Esben Agerlin Olsen
HØRING: Prøveboring efter skifergas har slidt på kommune og borgere.
Netbutikker har markant flere antibakterielle sølvprodukter på hylderne
Steffen Foss Hansen
13/10/2016

Description
Antallet af hverdagsprodukter med bakteriebekæmpende sølv i nanopartikelform er vokset med 80 procent på bare fire år, viser tal fra DTU Miljø. Men selv kan skabe antibiotikaresistente bakterier og skade miljøet.
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Netbutikker har markant flere antibakterielle sølvprodukter på hylderne
13/10/2016
DR (National), Denmark, Web
Thomas Lemke, Helle Slejborg, Simon Risum Pedersen
https://www.dr.dk/nyheder/penge/kontant/netbutikker-har-markant-flere-antibakterielle-soelvprodukter-paa-hylderne
Antallet af hverdagsprodukter med bakteriebekæmpende sølv i nanopartikelform er vokset med 80 procent på bare fire år, viser tal fra DTU Miljø. Men selv kan skabe antibiotikaresistente bakterier og skade miljøet.
Steffen Foss Hansen
Press/Media: Press / Media

Ph.d.-forsvar om at vurdere risikoen for udsættelse for nanomaterialer i arbejdsmiljøet ved hjælp af control-banding værktøjer
Steffen Foss Hansen
27/09/2016
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Ph.d.-forsvar om at vurdere risikoen for udsættelse for nanomaterialer i arbejdsmiljøet ved hjælp af control-banding værktøjer
27/09/2016
Arbejdsmiljøforskning.dk (National), Denmark, Web
Kirsten Rydahl
http://www.arbejdsmiljøforskning.dk/da/nyheder/arkiv/2016/ph-d--forsvar-om-risikovurdering-af-nano-i-arbejdsmiljoeet-vha-control-banding-vaektoejer
Steffen Foss Hansen
Press/Media: Press / Media

Commission seeks input to third nanomaterials regulatory review
Steffen Foss Hansen
23/06/2016

Description
Interplay between REACH and CLP key, says NGO
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Commission seeks input to third nanomaterials regulatory review
23/06/2016
Chemical Watch (International), Web
Luke Buxton
https://chemicalwatch.com/48240/commission-seeks-input-to-third-nanomaterials-regulatory-review?q=steffen+foss+hansen
Steffen Foss Hansen
Press/Media: Press / Media
Debat: Nej, skifergas er da alt andet end forsvarligt
Steffen Foss Hansen
23/02/2016

Description
SKIFERGAS Politikerne må enten forbyde skifergas eller indrømme, at de gambler med miljø og sundhed.
Department of Environmental Engineering, Environmental Chemistry

Media coverage (1)

Debat: Nej, skifergas er da alt andet end forsvarligt
23/02/2016
Politiken (National), Denmark, Print
Jens Voldby Crumlin
374 words
SKIFERGAS Politikerne må enten forbyde skifergas eller indrømme, at de gambler med miljø og sundhed.
Steffen Foss Hansen

Relations
Projects:
Shale gas in a Danish context
Press/Media: Press / Media

Naturstyrelsen kortlægger erfaringer 36 farer ved skifergas i Danmark
Steffen Foss Hansen
19/02/2016

Description
Naturstyrelsen advarer om, at udvinding af skifergas kan føre til forurening af grundvandet, og at der er brug for mere viden om de kemikalier, der bruges til at udvinding.
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Naturstyrelsen kortlægger erfaringer 36 farer ved skifergas i Danmark
19/02/2016
Arbejderen (National), Denmark, Web
http://arbejderen.dk/indland/36-farer-ved-skifergas-i-danmark
Naturstyrelsen advarer om, at udvinding af skifergas kan føre til forurening af grundvandet, og at der er brug for mere viden om de kemikalier, der bruges til at udvinding.
Steffen Foss Hansen
Press/Media: Press / Media

Forskere står med mange ubesorvade skifergasspørgsmål: Der er stadig mange ubesorvade spørgsmål om skifergasboringernes konsekvenser for miljøet og grundvandet.
Steffen Foss Hansen
10/02/2016
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Forskere står med mange ubesorvade skifergasspørgsmål: Der er stadig mange ubesorvade spørgsmål om skifergasboringernes konsekvenser for miljøet og grundvandet.
10/02/2016
Energisten, Web
Morten Kammersgaard
http://energisten.mediajungle.dk/2016/02/10/forskere-staar-med-mange-ubesvarede-skifergasspoeergsmaal/
Steffen Foss Hansen
Department of Environmental Engineering, Environmental Chemistry

Relations
Projects:
Shale gas in a Danish context
36 risici ved at bore efter skifergas
Steffen Foss Hansen
03/02/2016

Description
Regeringsrapport peger på, at der er 36 risici ved at bore efter skifergas. Ifølge lektor ved DTU Steen Foss Hansen er der dog behov for yderligere undersøgelser.
Department of Environmental Engineering, Environmental Chemistry

Media coverage (1)

36 risici ved at bore efter skifergas
03/02/2016
Danskfjernvarme.dk, Denmark, Print
Dansk Fjernvarme
162 words
Steffen Foss Hansen

Relations
Projects:
Shale gas in a Danish context
Press/Media: Press / Media

Rapport: Sådan gør vi skifergas miljøvenlig
Steffen Foss Hansen
02/02/2016

Description
Der er en række miljømæssige risici ved at bore efter skifergas, men en ny rapport fra Naturstyrelsen bringer mulige løsninger for dagen.
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Rapport: Sådan gør vi skifergas miljøvenlig
02/02/2016
Ingeniøren (National), Denmark, Web
Julie Lykke-Nedergaard
461 words
https://ing.dk/artikel/rapport-saadan-goer-vi-skifergas-miljovenlig-181929
Der er en række miljømæssige risici ved at bore efter skifergas, men en ny rapport fra Naturstyrelsen bringer mulige løsninger for dagen.
Steffen Foss Hansen

Relations
Projects:
Shale gas in a Danish context
Press/Media: Press / Media

Sådan gør vi skifergas miljøvenlig: Der er en række miljømæssige risici ved at bore efter skifergas, men en ny rapport fra Naturstyrelsen bringer mulige løsninger for dagen
Steffen Foss Hansen
02/02/2016
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Sådan gør vi skifergas miljøvenlig: Der er en række miljømæssige risici ved at bore efter skifergas, men en ny rapport fra Naturstyrelsen bringer mulige løsninger for dagen
02/02/2016
Ingeniøren, Web
Julie Lykke-Nedergaard
Nanoteknologien buldrer frem på arbejdspladserne
Steffen Foss Hansen
11/11/2015

Subject
Nr. 11 - 2015
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Nanoteknologien buldrer frem på arbejdspladserne
11/11/2015
Arbejdsmiljø, Print
Birgit Bruun Christensen
Steffen Foss Hansen
Department of Environmental Engineering, Environmental Chemistry

Description
Man kan ikke se en nanopartikel med det blotte øje. Nogle er sundhedsskadelige, mens andre er helt ufarlige. En af de store udfordringer for arbejdspladserne er at få overblik over, om der er nano i arbejdsmiljøet – og derefter at tage de rigtige forholdsregler.

Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Interview
02/11/2015
Magasinet Arbejdsmiljø (National), Denmark, Print
Birgit Bruun Christensen
Magasinet Arbejdsmiljø Nr. 11 2015 side 20-24
https://mitarbejdsmiljo.dk/search/node/steffen%20foss%20hansen
Steffen Foss Hansen

Kulstofnanorør kan blive vor tids asbest
Steffen Foss Hansen
21/09/2015
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Kulstofnanorør kan blive vor tids asbest
21/09/2015
Ingeniøren (National), Denmark, Web
https://apps-infomedia-dk.proxy.findit.dtu.dk/mediearkiv/link?articles=e538ebaa

Steffen Foss Hansen

Første maling i Danmark med kulstofnanorør vækker bekymring
Steffen Foss Hansen
21/09/2015
Kulstofnanorørerne er så mikroskopiske, at de kan udrette betydelig skade på lungerne, hvis de bliver indåndet. Den første maling med kulstofnanorør er netop kommet på makredet til professionelle. For fire år siden blev malingen Tesla Nanocoating kåret som en af de 100 bedste opfindelser af R & D Magazine. Nu er malingen kommet på det danske marked for professionelle malere - og nu vækker malingen bekymring hos flere eksperter. Årsagen er malingens indhold af kulstofnanorør. Det skriver dagbladet Ingeniøren.

Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Første maling i Danmark med kulstofnanorør vækker bekymring
21/09/2015
Byggecentrum.dk (National), Denmark, Web
Byggecentrum.dk
https://molio.dk/bygnet/nyhed/article/foerste-maling-i-danmark-med-kulstofnanoroer-vaekker-bekymring/
Kulstofnanorørerne er så mikroskopiske, at de kan udrette betydelig skade på lungerne, hvis de bliver indåndet. Den første maling med kulstofnanorør er netop kommet på makredet til professionelle. For fire år siden blev malingen Tesla Nanocoating kåret som en af de 100 bedste opfindelser af R & D Magazine. Nu er malingen kommet på det danske marked for professionelle malere - og nu vækker malingen bekymring hos flere eksperter. Årsagen er malingens indhold af kulstofnanorør. Det skriver dagbladet Ingeniøren.

Steffen Foss Hansen
Press/Media: Press / Media

Kulstofnanorør kan angribe lungerne
Steffen Foss Hansen
21/09/2015

Description
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Kulstofnanorør kan angribe lungerne
21/09/2015
Ingeniøren, Print
Bjørn Godske
Steffen Foss Hansen
Department of Environmental Engineering, Environmental Chemistry
Press/Media: Press / Media

Experts call for focus on hazards of emerging technologies
Steffen Foss Hansen
21/08/2014

Description
Danish experts are calling for increased environmental, health and safety (EHS) funding to improve prediction of potential hazards from emerging technologies, while also maximising commercial lifespan.
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Experts call for focus on hazards of emerging technologies
21/08/2014
Chemical Watch (International), Web
Chemical Watch
https://chemicalwatch.com/20953/experts-call-for-focus-on-hazards-of-emerging-technologies
Danish experts are calling for increased environmental, health and safety (EHS) funding to improve prediction of potential hazards from emerging technologies, while also maximising commercial lifespan.
Steffen Foss Hansen
Press/Media: Press / Media
Experts call for focus on hazards of emerging technologies
Steffen Foss Hansen
21/08/2014
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Experts call for focus on hazards of emerging technologies
21/08/2014
Chemical Watch, Print
Steffen Foss Hansen
Department of Environmental Engineering, Environmental Chemistry
Press/Media: Press / Media

Nu skal nanoprodukter registreres
Steffen Foss Hansen
17/06/2014
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Nu skal nanoprodukter registreres
17/06/2014
Lemvig Folkebladet (Regional), Denmark, Web
Marianne Fajstrup
644 words
Steffen Foss Hansen
Press/Media: Press / Media

Regeringen vil bruge 24 millioner på et nano-register
Steffen Foss Hansen
12/11/2013
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Regeringen vil bruge 24 millioner på et nano-register
12/11/2013
DR, Web
Christine Hyldal og Peter Skaustrup
http://www.dr.dk/nyheder/politik/11233723.htm
Steffen Foss Hansen
Department of Environmental Engineering, Environmental Chemistry
Press/Media: Press / Media

Lessons nanotechnology can learn from past mistakes
Steffen Foss Hansen
16/09/2013

Description
Falling in love with a new technology and wanting to apply it everywhere is not a good idea
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

Lessons nanotechnology can learn from past mistakes
16/09/2013
The Guardian, Web
Michele Catanzaro
http://www.theguardian.com/science/small-world/2013/sep/16/nanotechnology-lessons-safety
Steffen Foss Hansen
Department of Environmental Engineering, Environmental Chemistry
Press/Media: Press / Media
The tiniest particles that may be a threat as bad as asbestos
Steffen Foss Hansen
27/01/2013

Description
Nanomaterials are everywhere, but their use is totally unregulated.
Department of Environmental Engineering, Environmental Chemistry

Media contribution (1)

The tiniest particles that may be a threat as bad as asbestos
27/01/2013
The Independent , Web
Emily Dugan
Steffen Foss Hansen
Department of Environmental Engineering, Environmental Chemistry
Press/Media: Press / Media