Emerging Risk Nanotechnology

Emerging Risk Discussion Paper

Author

Dr. Gerhard Schmid
Munich Re
Tel.: +49 89 38 91-98 69
gschmid@munichre.com

February 2017

Executive summary

Nanotechnology is a multidisciplinary field, covering a vast and diverse array of devices derived from engineering, biology, physics and chemistry. Many experts are of the opinion that nanotechnology will prove to be one of the key technologies of the 21st century. The term "nanotechnology" is generally used to refer to objects whose size is within the range of 0.1 to 100 nm. This range corresponds to the size of individual atoms up to that of viruses. The possibilities for nanotechnology seem endless.

Four essential characteristics of nanomaterials distinguish them from "traditional" materials of larger size:

- **quantum mechanical behaviour** (results in different electrical and magnetic properties)
- **small dimensions** (permit new transport routes, e.g. through the intestinal wall into the blood)
- **large relative surface area** (results in greater chemical reactivity)
- **molecular shape** (e.g. permits specific docking to certain viruses)

Every advance brings with it an associated risk. This is also true of nanotechnologies, although not very much is known. Research on the *risks* of a new technology generally lags years behind that on the *benefits* of the technology. This makes it difficult for society, and also for the insurance industry, to undertake a robust risk assessment. It also imposes a need for continuous and careful monitoring of new developments in the area concerned.

Risks of nanotechnology

Nanotechnology has the capacity to help solve many of society's problems. Equally important, the failure to develop new technologies responsibly could not only place nanotechnology in the same crowd as GMOs and nuclear energy. Fortunately many organizations are actively pushing for risk assessment before anything could go wrong.

To be fair, nanoparticles are not a new phenomenon (they are found in volcano ash, ocean spray, smoke, clouds, and clay after all). Depending on where it is, a cubic meter of air will contain hundreds of millions of nanoparticles, most of which are of natural origin or else – like diesel soot, for instance – are products of combustion processes. However, scientists warn that the idea of free born, manmade, and active particles is a risk that is in fact new due to the physical characteristics of the material. Also, deliberately produced nanoparticles are often more bio persistent than soot or naturally occurring nanoparticles.

While understanding the risks of new products, it is important to keep in mind that a balanced analysis must be made between the benefits of new technologies with their downsides. Some particles may harm the body but some may also help the fight against cancer for example.

Human health (toxicity)

As more new products enter the market, the risk for human health is increasing. The small scale of nanomaterials makes them much more reactive and also enables them to cross cell membranes. Because properties are dramatically different at the nano scale it is difficult to predict how a nanoparticle will react.

In general, nanomaterials such as are used in the computer and electronics industry can be regarded as being somewhat less harmful than nanoparticles and nanofibers. In addition, nanocomposites – solid bodies that contain nanoparticles – probably pose less of a risk to health than do free particles or nano dispersions emitted by a spray bottle. Particular caution is required with any product that is intended for use in humans, such as skin creams, medicines and biomarkers.

The most likely forms of exposure come through the inhalation and digestion. For example, the use of sprays designed to seal various types of surface could potentially result in inhalation of tiny droplets containing nanoparticles. Similarly, abrasion associated with the use of nanocomposites (tires, sporting equipment, etc.) could result in release of nanoparticles.

Once they have passed these barriers, they can potentially be distributed via the bloodstream to the whole body.

Workplace exposure

The most likely venues for exposure in the short term are in factories producing nanoparticles and in academic settings. In many nanoparticle-containing products such as car paints and nanocomposites, the nanoparticles form an integral part of the material. Nevertheless, during the manufacture of such products the particles are almost always present in the form of a powder or at least a dispersion. It is precisely this phase of the manufacturing process that can be critical for the health of workers. Comparisons with claims related to silica dust exposure urge a need for caution: regular occupational contact with nanoparticles could likewise cause chronic disease. Such consequences often become apparent only decades after exposure, by which time there is little possibility of limiting the damage.

In cases of doubt, the toxicity of nanoparticles is better overestimated than underestimated. Many particles, for example nanotubes, may well be rather more toxic than other particles. Production should therefore take place only with certain safety precautions.

The disposal of nano products could also pose health risks to employees. One need only to think of non-stick coatings during the demolition of buildings or of exploding nano sprays in garbage incinerators. As there is generally a period of years or even decades between production and disposal, the relative danger or safety of the materials concerned ought to be known. In many cases, however, it will be difficult to determine whether a product does or does not contain a given type of nanoparticle. This is due firstly to the absence of any obligation to label nano products as such, and secondly to the fact that nanoparticles are invisible both to the naked eye and to the light microscope.

The environment

Nanotechnology could offer environmental benefits. For example, materials are used more efficiently as devices are miniaturized and materials can be made more energy efficient saving power. Also, filters can allow for pollution to be removed, water to be cleaned (maybe even desalinized), and optimize exhaust emissions of vehicles. Cleanup of heavy metals in soil, and even applications for oil spill cleanup are exciting as well.

It is also important, however, to look at the risks for the environment. Unfortunately, there are almost no studies on the toxicology of nanoparticles in the environment. One study has been done on fish, a few on rodents, but much more work needs to be done.

Many scenarios exist for ecosystems to become polluted. Nanoparticles could escape into the environment as a result of accidents, leaks and even as a result of normal use or transport of nanotechnological products. In one field study, iron nanoparticles were found to move a distance of about 20 meters with the groundwater. On the other hand, creeks and rivers might be able to carry particles much further. It is unknown whether contamination of the soil and of groundwater could affect the supply of drinking water and also for agricultural products such as meat and vegetables. As an extreme example, one could imagine an explosion in a nanoparticle factory resulting in toxic particles being scattered over a wide area and then spread even further by the wind. This could render a whole tract of land both uninhabitable and useless for agricultural purposes. Unfortunately, there are not nearly enough studies on transport pathways, biogeochemical cycling and environmental fate of nanomaterials once in the environment.

In the long term, the chance for environmental damage and exposure increases as nanoparticles become more prevalent. Given the large increase in nanoparticle production in the future, a buildup in the soil and water seems to be the most significant exposure avenue. This is important because the ability to penetrate into live cells means that nanoparticles could accumulate in organisms and thus, also in the food chain.

Nano applications

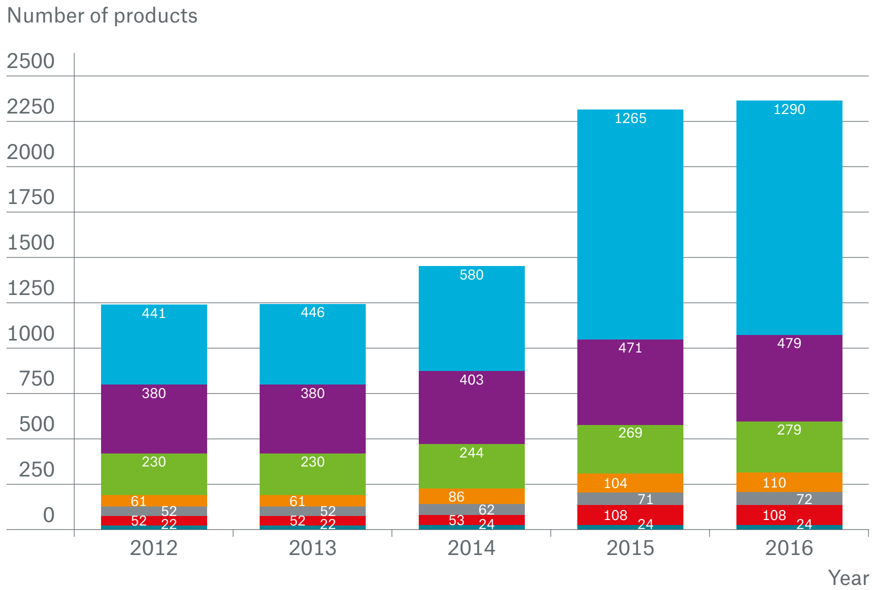
Nanotechnology is a crossover technology. One characteristic is, that this technology is not fixated on one product line. It is found in thousand different products. The scope of these products can be divided in different categories. Approximately 50% of all nano applications are found in the product segment of health and fitness, followed by home and garden (19%) and automotive (11%). The rest is separated into cross cuttings, food and beverages and appliances (detailed information see figure 1). The number of nano products is soaring over the course of time; a duplication is observable of the total number of nano products since 2012 (see figure 2).

Figure 1: Nano applications and product lines
(http://www.nanotechproject.org)

Appliances	4%
Automotive	11%
Cross cuttings	7%
Electronics and computers	5%
Food and beverages	6%
Health and fitness	48%
Home and garden	19%

Figure 2: Development of nano consumer products
(http://nanodb.dk/en/analysis/consumer-products)

Health and fitness
Home and garden
Automotive
Electronics and computers
Appliances
Food and beverages
Goods for children



In order to better analyze the associated risks of different materials, a detailed classification system has been created by Munich Re experts (see figure 3). The first column of the chart defines the general risk exposure in five different groups: Group I, is the one with the highest risk exposure, due to the nature of the material used (free nanoparticles, nanotubes and nano machines). The more nano products are intended for use in humans – such as skin creams, medicines and biomarkers (see Group II) – the more the segments health and safety are exposed. Group III to V (e.g., powders and coatings) represent a decreasing order of risk exposure. Group III nano products, like nano spray or paints can be freed when used. Group IV products are fixed or embedded in solid objects and own therefore a lower risk exposure. Group V – the conventional nano products generally do not come into contact with the body like the Groups I–III, but could likewise constitute a risk to health under certain circumstances.

The second column of the table describes by way of example individual products; the third column "Lines of Business" affected and the last one the expected type of loss.

Figure 3: Munich Re's classification system for nano products

Group	Product	Lines of Business Affected	Type of Loss
I Free nanoparticles or nanotubes and nanomachines	Nano powder and active nano products	WC, product liability, product recall, ELD, EIL, public liability	
II Nano products in food, drugs and cosmetics	Nano ingredients in drugs, cosmetics, dental fillings and food additives	Product liability, product recall, EIL, public liability, pharma, medical malpractice	
III Nano products that can be freed when used, applied or disposed of	Nano spray, paints (nanoparticles on and in solid objects, when freed)	Product liability, EIL, product recall, ELD, public liability	Bodily injury, property damage, pure financial loss
IV In nano products fixed and embedded nanoparticles	Nano sealing, coating on solid objects		
V Conventional nano products	Electrical and household equipment	Product liability, product recall	

Lines of business affected

Product liability
In particular, product liability could take on new dimensions in view of the complexity of the potential applications of nano products such as surface coatings, powders or similar products, already manufactured using non-nanotechnology methods and often featuring the following much-debated causes of loss:

- *Development errors:* These occur at the stage prior to mass production of the item. Usually, the result is that all products of that type are rendered unfit for the intended purpose.

- *Design errors:* These may arise before, but also during, mass production of the article. The effect of this type of error is that the goods produced are unfit for the intended purpose.

- *Faulty manufacture:* Although the product is essentially fit for the intended purpose, individual components (outliers) or particular batches of the articles have defects (serial losses) resulting from production errors, which can result in loss or damage for the purchaser or final consumer.

- *Information errors:* In this case, the cause of loss is not a flaw in the product itself but misleading or incomplete advice or erroneous instructions for use. This can lead to risks either in actual use of the product or because it is incorrectly stated to be fit for certain purposes.

- *Product monitoring:* Due to a lack of product monitoring in the market, the defects which occur during application and use of the product in practice go unrecorded. Consequently, they cannot be passed on to research and development for product optimization purposes.

Product recall
In view of the innovative nature of the manufacturing methods and consequently increased risk of teething problems, there are likely to be more frequent product recalls.

As recalls are not covered under product liability as a general principle, insurance companies can expect an increasing demand for product recall policies.

Due to the limited experience with nano products (new products, new technologies and new product developments) the risk in product liability and recall of faulty products are increased (over-all risk evaluation for the discussed LoB see the following figure 4).

Environmental impairment liability/ General liability
The manufacture of nanotechnology products will aggravate the conventional risks of third-party losses and damage to natural resources. Not only people, property and capital but also the environmental constituents of earth, air and water are threatened by losses in any number of laboratories, manufacturing plants, warehouses, waste management and outdoor trial areas, as well as by damage caused by the products themselves.

Workers' compensation/ Employer's liability
The special features of nanotechnology with its infinitely small-scale products make it essential that sterile, clean room technology working conditions are provided to protect employees. Nonetheless, accidents could happen, causing breakdowns in the sealing system.

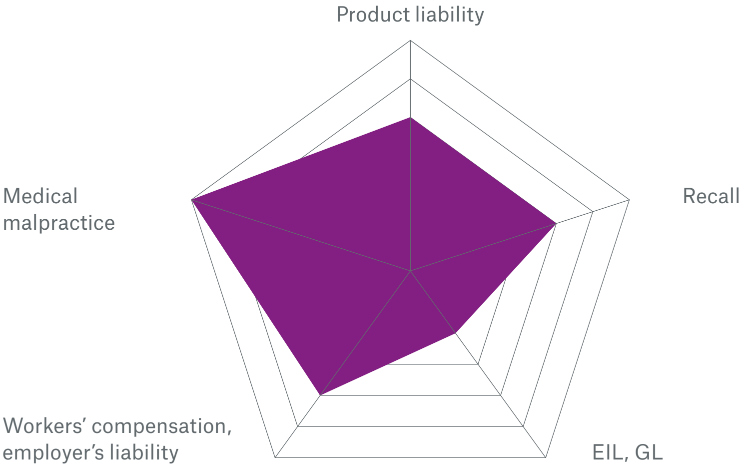
Medical malpractice
Med Mal insurance for hospitals and community- based physicians will doubtless be subjected to increased risk of loss due to the use of nanotechnology, as is the case with current medical therapy techniques. This issue has three important aspects:

- Nanotechnology changes atoms and molecules and so encroaches on a sensitive area which is prone to errors and oversights. The type of therapy is so to say brand new.

- There may also be unforeseeable interactions with other therapies.

- Nanotechnologically created products, which can sometimes have unpredictable effects, are administered to patients.

Figure 4: Over-all risk evaluation of the LoBs
(Med Mal = high, PL, Recall and WC/EL = medium, EIL/GL = low)



Conclusion

Nanotechnology is a field of enormous economic potential. As the growth of various industries is enhanced by nanomaterials it is important for risk assessment to keep pace.

In the end, a responsible approach will help to minimize harmful side effects and keep nanotechnology in the positive eye of the public. Risk analysis needs to be continuously updated. Manufacturers need to strive to prevent damage from occurring by holding themselves to high quality standards.

Existing regulations, recommendations, and precautionary measures are the fundament of very strong risk management and risk assessment in the field of manufacturing nano products, which allows the industry a safe and a sustainable production under state-of-the-art technology. Not only is this important during the manufacturing of a product, but through the entire lifespan of the product.

Setting up risk dialogues, discussion and decision-making organs on a regular basis with all involved social, corporate, ethical and political levels can guarantee, that possible threats and exposures of nanotechnology will be sufficiently discussed. All interested parties have a chance to voice an opinion on an early stage as well. Risk dialogue and information programmes can make an important contribution to raising public awareness, reassuring the public and improving risk management.

The implications for insurance demand attention, as more or less all LoB are affected to some extent.

NOT IF, BUT HOW

© 2017
Münchener Rückversicherungs-Gesellschaft
Königinstrasse 107, 80802 München, Germany

Münchener Rückversicherungs-Gesellschaft (Munich Reinsurance Company) is a reinsurance company organised under the laws of Germany. In some countries, including in the United States, Munich Reinsurance Company holds the status of an unauthorised reinsurer. Policies are underwritten by Munich Reinsurance Company or its affiliated insurance and reinsurance subsidiaries. Certain coverages are not available in all jurisdictions.

Any description in this document is for general information purposes only and does not constitute an offer to sell or a solicitation of an offer to buy any product.