NANOTECHNOLOGY

THE CHALLENGE OF INSURING AGAINST A MULTI-FACETED AND POORLY UNDERSTOOD LATENT EXPOSURE

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I. WHAT IS NANOTECHNOLOGY?

Nanotechnology is a technological revolution that is not only going to play a large part in all of our lives, but, unbeknown to many of us, is already doing so.

The nanoscale is 1,000 times smaller than the micro scale, which is the scale traditionally associated with the electronics industry. One nanometre is 1 billionth of a metre. That is the size of 10 hydrogen atoms. The same size as you will get if you split a human hair about 80,000 times. If you have printed this paper, the sheet on which it is printed will be about 100,000 nanometres thick. Put another way, a nanometre is to 1 inch is what 1 inch is to 400 miles.

Nanotechnology operates at sizes below about 100 nanometres. However, as in many emerging disciplines, there is no consensus as to the definition of nanotechnology.

Lloyd's Emerging Risks Team in their 2007 report *"Nanotechnology, Recent Developments, Risks and Opportunities"* ("the Lloyd's Report") describe nano products as:

> *"A class of product containing materials built on the atomic scale".*

(http://www.lloyds.com/~/media/lloyds/archive/lloyds%20market%20gallery/lloyds%20market%20gallery/er_nanotechnology_report.pdf.) (last visited 4/23/15).

The EPA defines nanotechnology as *"the deliberate engineering of particles by certain chemical and/or physical processes to create materials with specific properties different than their macro scale counterparts".* The EPA goes on to state that this definition does not include unintentionally produced nanomaterial, nano-sized particulate or materials that occur naturally in the environment (e.g viruses, volcanic ash and sea spray) or nanoparticle by-products of human activity (such as diesel exhaust particulars or other friction or airborne combustion by-products).

The National Nanotechnology Initiative, which coordinates the nanoscale sciences of 26 Federal US Agencies, defines nanotech in a rather more digestible manner:

> *"The understanding and control of matter at dimensions of roughly 1 to 100 nanometres, where unique phenomena enable novel applications."*

(http://www.nano.gov/nanotech-101/nanotechnology-facts) (last visited 4/23/15).

So what is special about nanomaterials, other than their nano-size, which enables these *"novel applications"*? The chemical reactivity of a material is related to its surface area as compared to its volume. Dissecting a 1 centimetre cube of material into 1 nanometre cubes, increases the total combined surface area some 10 million times. Nanoparticles can therefore be much more reactive than larger volumes of the same substance. The properties of materials change when brought to the nanoscale. This can include changes in:

- Colour
- Conductivity
- Reactivity
- Electrical properties
- Magnetic properties
- Toxicity

As reactivity increases, the harmful effects of a substance may also increase.

II. NANO PRODUCTS

Although the nanotechnology field is in its relative infancy, it has seen phenomenal growth over the last decade (notwithstanding the recession). In 2008, there was already some US$32 billion worth of nano-enabled products globally. By 2011, this had grown to US$336 billion. In 2013, there were around 5,400 nanotech firms globally, the largest proportion being in the USA (especially California), but also a significant proportion in the UK. It has been estimated that this year the figure for nano products will reach US$2.6 trillion, and that nanotech will be used in relation to 15% of all products on the market. Of course, it remains to be seen whether this prediction will be proven accurate.

There are some 5,000 types of nanomaterial. Their possible uses involvenumerous fields, including drug delivery, diagnostics, tumor killers, small powerful batteries, materials 100 times stronger than steel and 8 times lighter, cars that absorb more impact, super-efficient fuels cells, the facilitation of

environmental clean-up and many others. There is no doubt that the potential benefits of the application of nanotechnology are enormous.

Their use already exists in everyday life. There are nano products on your skin, sunscreen, moisturizers, makeup, in our food supply (for example, olive oil), on our roads (asphalt sealants, tires), in our clothing (sports jackets, slacks, socks, bras), in personal care products (toothpaste), in diesel fuel (petroleum additives in the UK), in paints, in home building products, in sports equipment (tennis rackets, hockey sticks, artificial turf), in performance gear, in electronics (the IPhone), in medical devices, in medicine, in food packaging and even in the water you may drink (as a water purifier). The list goes on … and on.

Plasters with a nano-coating of silver (see III. B 2 below) allow wounds to heal more quickly. Nano-technology used in a new breath test has been found to be effective in detecting stomach cancer quickly and cheaply. Nanoparticles are used in container liners for foods and can assist the easier flow of tomato sauce from the bottle. They can enable anti-aging products to seep into our pores. They are used in sunscreens to similar effect, and this is why lifeguards and various sportsmen are no longer seen with white stuff on their noses. It is the titanium dioxide nanoparticles in the sun cream that make it more effective, clearer and longer lasting. Carbon nanotubes have a tensile strength 10 times greater than steel, but make for a far lighter material – they are considered the strongest material for weight known to mankind.

There are clearly spectacular advantages and advances that are being and can be made by the application of nanotechnology to a very broad spectrum of disciplines and products.

III. NANO RISK

Depending on what they have been used for, nanoparticles can be indigested, absorbed through the skin, or inhaled. A plethora of medical and scientific articles have raised concern regarding nanomaterials. It is clear they act differently than their macro counterparts in animal and environmental studies. They clearly cause biological responses that have been associated with precursors of certain diseases (i.e an inflammatory response) and have the ability to migrate through the body at the cellular level. Whether these biological effects will eventually lead to diseases as a result of cumulative exposure remains unknown. In the environment, nanoparticles will be persistent and transitory, and those effects are unknown ecologically.

There is a consensus from governments, scientists, corporations, activists, researchers and educational institutions that there are many unknowns as to the short and long term effects nanomaterials may have on humans, ecosystems and the environment. Presently, adequate assessment models havenot been totally defined, developed, adopted, implemented or enforced to measure what effects this nano-revolution will have on mankind and the environment.

However, a number of potential risks have been identified, of which the following are a just a few examples:

A. Nano Titanium Dioxide

The Lloyd's Report discussed concerns that nano-sized particles of titanium dioxide (which, as noted above, is used in sunscreen) once rubbed into the skin would be able to enter cells and damage them. It notes that titanium dioxide exposed to sunlight can act as a photo catalyst which can be very toxic to surrounding cells:

> *"The short term effects on cells is that if the nanoparticles can penetrate the dead layer of skin that protects the body then titanium dioxide may be toxic when exposed to sunlight. The long term effect is unknown and requires further research".*

B. Nano Silver

A study from the University of Southern Denmark, results published in the journal ACS [American Chemical Society] Nano dated February 2014 (http://pubs.acs.org/doi/abs/10.1021/nn4050744) found that nano-silver leads to the formation of harmful "free radicals" in cells, and changes in form and amount of protein. A number of serious diseases are characterized by the fact that there is an overproduction of free radicals in cells, such as Azheimer's, Parkinsons, and cancer.

C. Carbon Nanotubes

Similar to asbestos, the structure and length of carbon nanotubes influences whether the fibres are retained and cause inflammatory changes or are expelled by the body. Carbon nanotubes that *"exist as compact tangles of nanotubes"* may pose greater risk of pleural pathology than do the *"long and straighter"* nanotubes (as reported by Ken Donaldson and others in their 2010 article entitled "*Asbestos, Carbon Nanotubes and the*

Pleural Mesothelium: a review of the hypothesis regarding the role of long fiber retention in the parietal pleura, inflammation and mesothelioma," http://www.particleandfibretoxicology.com/content/7/1/5 (last visited on 4/23/15). Multi-walled carbon nanotubes may have similar genotoxicity and inflammatory effects on mesothelial cells as do long amphibole fibres. Several studies have demonstrated that long carbon nanotubes *"showed a similar or greater propensity to produce inflammation and fibrosis in the peritoneal cavity, to that produced by long asbestos"*(ibid). Carbon nanotubes introduced into the abdominal cavity of mice showed asbestos-like pathogenicity in a pilot study. In particular, a 2011 study by Fiona Murphy and others found that the direct deposit of both long and short carbon nanotubes in the pleural cavity *"produced asbestos like length dependent responses." See,* American Journal of Pathology, v.178(6); 2011 JunPMC3124020) (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3124020/) (last visited 4/23/15)

Further research in 2013 suggested that the risk of asbestos-like behaviour could perhaps be ameliorated by shortening the carbon nanotubes, but a paper accepted by the Royal Society of Chemistry in August 2014, and published in its journal on 29 September, is summarized by the Royal Society of Chemistry's blog as suggesting that *"if inhaled, CNTs may deposit in the respiratory system and cause a health risk similar to that of asbestos*." See, "*Towards elucidating the effects of purified MWCNTs on human lung epithelial cells*" Chenbo Dong Reem Eldawud, Linda M. Sargent, Michael L. Kashon, David Lowry, Yon Rojanasakulc and Cerasela Zoica Dinua: Environ. Sci.: Nano, 2014,1, 595-603 DOI: 10.1039/C4EN00102H, http://pubs.rsc.org/en/Content/ArticleLanding/2014/EN/c4en00102h#!div Abstract(last visited 4/23/15).

Turfgrass Producers International, in its e-newsletter dated June/July 2011, highlighted the problem of black nanoparticles and carbon nanotubes, found in the pulverized tires and tire crumb that is the most common infill used on artificial turf playing fields in the USA. Carbon black nanoparticles make up 30% or more of car tires. A study posted by Nature Nanotechnology led by the Queen's Medical Research Institute at the University of Edinburgh/MRC Centre for Inflammation Research in Scotland (http://www.scientificamerican.com/article/carbon-nanotube-danger/), suggested that long, needle-thin carbon nanotubes could lead to

lung cancer, and inhaling carbon nanotubes could be as harmful as breathing asbestos.

Since then, other researches have expressed concern. The National Institute for Occupational Safety and Health (NIOSH) reported their research methods demonstrated that breathing nanoparticles may result in damaging health effects. NIOSH scientists invented a way to suspend nanotubes in the air, allowing the concentration of particles to be carefully controlled. Mice were placed into such an environment, where they could breathe the air containing the particles. Scientists studied the effects of exposure after 1, 7 and 28 days. The research showed early indications of serious health outcomes that may have longer term effects, such as cancer, indicating the need for ongoing research to more clearly understand the implications of exposure.

Peter Gehr, a professor of Histology (the study of tissue) and Anatomy at the University of Bern in Switzerland, stated that synthetic nanoparticles can penetrate tissue and cells and spread throughout the body, even to the brain. He expressed astonishment that potential health risks of synthetic nanoparticles are barely acknowledged outside the scientific world and government agencies, stating *"if nanoparticles are not solidly bound to another material, there is a risk we could inhale them. They can enter the bloodstream and spread throughout the entire body. The mere fact that particles penetrate into the body is a problem"* (Natural Resources in Switzerland – Environment – Nanotechnology 3/20/2010, Federal Office for the Environment).

It follows that nanoparticles can penetrate into tissue and cells and spread throughout the body via the bloodstream. Indeed, the University of Bern, Institute of Anatomy, has produced a photograph of red blood cells, using a laser-scanning microscope, which shows nanoparticles that have penetrated the cells (Turfgrass Producers International E-newsletter June/July 2011). Another report published online on July 26, 2014 found that carbon nanotubes stimulated blood platelet activation, leading to serious and devastating clotting.
(http://www.nanomedjournal.com/article/S1549-9634(14)00415-8/abstract and also published in the January 2015 edition of Nanomedicine).

IV. HAS DAMAGE BEGUN TO MANIFEST?

It is in the very nature of particles that may seep into the environment or cause long term health hazard through, for example, carcinogenic effects, that the damage may not manifest itself for some considerable time after exposure. This we have learned most spectacularly from asbestos, but also from other products. Nevertheless, fingers are already being pointed at alleged adverse effects caused by nanoparticles in products. In a report for the NBC network published on 8 October 2014, which can be accessed on their website, Hannah Happlye drew attention to what she considered to be a disproportionate number of young soccer goalkeepers suffering cancers. Goalkeepers come into greatest contact with the tire crumbs on artificial turf – a dive by a goalkeeper can send up clouds of such granules, which get into cuts, their mouths, etc. She reported that a soccer coach, Amy Griffin, following admittedly unscientific research, found that of 38 soccer players she identified with cancer, 34 were goalkeepers. The main cancers involved were blood related, mainly lymphomas. That article did not actually consider the issue of carbon nanoparticles in the tire crumbs, but pointed to the numerous constituents of tires and artificial turf, which make it difficult to identify any one cause. Indeed, no research has linked cancer to artificial turf, but equally little research has been done into the question. The fear is that the use of the technology may be running ahead of health, safety and environmental research.

The Turfgrass Producers International bulletin reported that, in August 2009, 7 young Chinese women suffered permanent lung damage and 2 of them died after working for months without adequate protection in a paint factory using nanoparticles.

One of the reinsurers that has been monitoring the situation for some time now is Gen Re. Charlie Kingdollar, Vice President of the Emerging Issues Unit of its Treaty Department, has produced various publications addressing nanotech risks. On 4 June 2014, he published a paper which can be found on the Gen Re website entitled *"First US case of illness arising from occupational exposure to nanomaterials"* (http://www.genre.com/knowledge/blog/first-us-case-of-illness-arising-from-occupational-exposure-to-nanomaterials-.html)(last visited 4/23/15).

This publication concerned a report that appeared in the American Journal of Industrial Medicine authored by Shane Journeay and Dr. Rose Goldman (Am. J. Ind. Med., p. 1 : Journeay and Goldman, "Occupational Handling of Nickel Nanoparticles: A Case Report,"). (http://www.researchgate.net/publication/262151024_Occupational_handling_of_

nickel_nanoparticles_A_case_report) (last visited 4/23/15). A 26 year old chemist working with nickel nanoparticle powder, with no protective measures, developed throat irritation, nasal congestion, post nasal drip, facial flushing and skin reactions to, for example, her earrings. Charlie Kingdollar cautions:

> *"Keep in mind that laboratory workers were believed to have less exposure to powdered nanoparticles due to better controls than may typically be found in a manufacturing setting ... as the Chicago song goes, "this may be only the beginning"".*

On 13 May 2014, the Magic City Morning Star described the report as *"game changing"*.

Jolinda Cappello, in an article published online by the American Society of Safety Engineers (*"Overview of Nanotechnology: Risks, Initiatives and Standardisation"*) (http://www.asse.org/practicespecialties/management/nantecharticle)(last visited 4/23/15) makes the points that:

> *"More than 2,000,000 US workers are exposed to nanoparticles on a regular basis, and that figure is expected to double as nanotechnology related industries increase worldwide. This raises fears that the growth of nanotechnology may outpace the development of appropriate safety precautions".*

Indeed, Charlie Kingdollar has in presentations on the subject drawn attention to the lack of such precautions taken both by researchers into nanoparticles and those involved in the manufacturing processes utilizing them. He also points to studies indicating, for example, that children's lungs are more susceptible to nanoparticles, that plastic nanoparticles are transported through the aquatic food chain (affecting fish metabolism behaviour), that poorly soluble nano-sized nickel particles may cause cancer in humans, that nanoparticles could disrupt immune cell function, that direct contact of nano-zinc oxide with colon cells cause the death of cells and that silver and titanium dioxide nanoparticles damaged testicular cells and DNA.

In addition to the litigation risks associated with occupational exposures, a New York Times report on a class action filed in March 2014 on behalf of individuals who experienced allergic reactions attributed to nickel nanoparticles used in "Fitbit" physical activity tracking bands signals that consumer claims will not be

far behind. http://www.nytimes.com/2014/08/21/technology/personaltech/nickel-allergies-on-rise-as-devices-meet-skin.html?_r=0 (last visited 4/23/15).

The Lloyd's Emerging Risks Team comments that research into toxicity is fragmented, but the risk of inhalation should be taken seriously. It considered the short term effects of certain nanoparticles and concluded:

> *"Long term exposure is still a big unknown however. If these nanoparticles can cause similar short term response in the lung as asbestos, it is possible that they may induce the same long term effects as well. Workers who produce these particles would be at the greatest risk and appropriate safety precautions, such as wearing nano-related masks, would reduce their exposure. This is still speculative and studies will have to be conducted to find a stronger link, but as an insurer it would be prudent to include this as a potential scenario when determining pricing and reviewing capital requirement"* (The Lloyd's Report).

That was 2007, before the reports potentially linking nanoproducts to injury. Yet in 2015 there is still a lot of work to be done. In March 2015 the National Nanotechnology Initiative (NNI) published the report from a workshop held in September 2013 which assessed the status of nanotechnology environmental, health and safety (EHS) risk science 3 years after the development of the NNI EHS Research Strategy. The report identified that dialogue is needed in 4 areas: communication resources (improved transparency in reporting the presence of engineered nanomaterials etc), decision tools (e.g. improved detection/characterisation tools), data resources (e.g. databases to facilitate access of information etc), standards and guidance resources in order to facilitate navigation of nanotechnology-enabled applications through the regulatory process etc). (http://www.nano.gov/).

In April 2015 The European Commission (EC) Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHIR) produced a Position Statement on emerging and newly identified health risks to be drawn to the attention of the EC. The primary purpose of the paper was to draw the attention of the E C to emerging issues in the non-food area that have been identified as having the potential to impact human health and/or the environment. It reported:

> *"Although nanomaterials used for drug delivery and imaging aim to reduce toxicity and side effects of drugs and imaging compounds, the carrier systems may impose risks to patients"*

and

> *".....the results foremost show that there are many risk related knowledge gaps to be filled.'*

(http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_s_002.pdf)

The Lloyd's Report had also concluded that there are unknown impacts on health and the environment, as well as many positive effects of nanotechnology. Herein lies the danger:

> *"... because the benefits are so seductive society may rush to capitalise on them before adequately assessing safety. The insurance industry must ensure that its own financial health is not compromised by systematic aggregations of loss from these technologies".*

V. ENVIRONMENTAL RISKS

Although the main focus of the research undertaken to date has been on nanotech health risks, nano materials also pose potential dangers to the environment. For example, nanoparticles can have a propensity to stick together (aggregate) or to fuse (agglomerate) effectively creating larger particles. This, in turn, will reduce the properties that are related to its size, such as chemical reactivity. When added to water, 50%-60% of copper nanoparticles aggregated and sank to the bottom. Hence, if a large number of nanoparticles were released into a water system (and remember one of the uses is for efficient environmental clean-up of other toxic waste - indeed nanomaterials were used in the Deepwater Horizon clean-up), the particles that agglomerate and sink can be absorbed by plants and animals. Once absorbed, they may behave in the same way as DDT and PCBs, namely by travelling up the food chain to larger animals, remaining in the environment for a long time. The concentration in animals and birds can then become toxic and cause organ injury and birth defects. At present there is no evidence that *"biological magnification"* of this nature would occur with nanoparticles, but it is an equally plausible prognosis based on past experience with DDT and PCBs, and there is no evidence that it would not happen. As with the situation so often, studies are required.

VI. INSURANCE RAMIFICATIONS

Subject to the proviso that the likelihood of such events is unknown due to lack of available research and knowledge of the risks, the Lloyd's Report identified the following potential scenarios that could result in large scale impacts to the insurance industry should they come to pass:

- Pollution spill from a nanoparticle production facility.
- Nanoparticle manufacturer workers developing chronic illness [the outcome subsequently addressed in the 2014 American Journal of Industrial Medicine Report discussed above].
- Nanoparticles leech from products to accumulate in the environment.
- Product recall due to research findings indicating a product is a hazard.
- Third party liability claims against businesses, directors and officers regarding a product that was indicated by research to be unsafe, but subsequently released to the consumer world.

The Lloyd's Report points out that each of these scenarios may require the insurer to pay for:

- Clean-up costs of land and water contamination.
- Medical costs of treatment of human exposure.
- Liability claims from persons directly affected, environmental groups and shareholders.
- Unexpected life, health and workers compensation.
- Latent liability claims of persons affected.
- Business interruption whilst facilities are investigated.
- Product recall costs.

This implicates a multiplicity of claims covering a number of different classes of insurance business and different insureds and insurers within those classes, potentially coming together as accumulations and aggregations of loss at the reinsurance level.

SwissRe's website includes a May 10, 2004 Report from its Chief Risk Officer (the "CRO Report") concerning "The opportunities and risks of nanotechnology from an insurance perspective" that reaches similar conclusions to the Lloyd's Emerging Risk Team's Report regarding the potential exposures and insurance ramifications.
http://www.swissre.com/media/news_releases/swiss_re_investigates_the_opportunities_and_risks_of_nanotechnology_from_an_insurance_perspective_.html
(last visited on 4/23/15). Essentially, these can be summarized as follows:

A. Health:

Nanoparticles can be inhaled, ingested or absorbed through the skin. There is evidence of differing adverse reactions to differing nanoparticles in animals and, at least in the short term, humans. Insufficient is known about the long term health consequences, but plausible risks can be identified from what is known and from applying past experience in other fields.

B. Environmental Risks:

Nanoparticles released into the air during production or use or as a waste by-product, may accumulate in soil, water and vegetation. Again, there is not enough known to establish whether this gives rise to a new non-biodegradable pollutant in itself and, if so, what its effects will be.

C. Financial:

The CRO report also identified the possibilities of securities claims and claims for financial loss, including those that could result from a collapse of stock prices. The report notes that three securities class actions have already been filed in the United States to recover harms attributed to allegedly false and misleading statements about the promises of nanotechnology. The settlement of the actions is reported to have been covered by professional indemnity insurers.

D. Defense Obligations:

In many jurisdictions, including the United States, insurers must pay for the defense of any claims which include allegations that may potentially be covered by the policy in question. The CRO paper points out that:

> *"Furthermore, the carrier has an affirmative duty to investigate the claims and look beyond the complaint to determine whether there is any potential liability for covered damages. The expense of the defense obligation often comes in addition to the limits of liability on the policy. As an emerging technology, nanotechnology may present previously untested loss scenarios, prompting claimants to advance novel legal theories and interpretations of policy language".*
>
> (http://www.thecroforum.org/nanotechnology/)

Hence, there is a significant exposure of insurers to defense costs, even if there turns out to be no liability.

E. Fear Claims:

There can be exposure to indemnity payments not only in respect of actual damage, for example for causing disease, but also for fear of disease. The CRO paper again points out that:

> *"At least three US Courts have addressed the issue of whether cell damage, without any associated symptoms or disability, is covered as "bodily injury" under standard liability policies. In the early stages of nanotechnology development, the lack of definitive scientific knowledge may increase the potential for claims alleging a "fear of future disease". Although decisions to date have been mixed, a significant number of US Courts may someday rule that such claims are both legally viable and covered by some policies".* (ibid)

The direct policies implicated in the above include Public Liability, Property, Employers Liability/Workmens Comp, Environmental Impairment, Life and Health, Product Liability/Product Recall, Directors & Officers and Professional Indemnity. Potential losses range from the immediate to the latent, with possible uncertainties as to which products caused a problem and when, giving rise to multiple potentially responsible insureds. The number of different ways in which

a product might cause a claim, the number of products, different potential insureds and claimants that might be involved, and the different policies and insurers impacted, all add up to potentially large accumulations and aggregations of loss, with all the issues that brings at the reinsurance level. There may be issues of aggregation, allocation to reinsured periods, trigger issues, occurrence issues and, no doubt, follow issues.

Last year XL Insurance posted on its website an article by Lijana Baublyte, Martin Mullins, Finbarr Murphy and Syed A.M. Tofail of the University of Limerick, Ireland, entitled "Insurance Market Perception of Nanotechnology and Nanomaterials Risks". They had used a combination of survey and interview methods to analyse insurers' perception of risks associated with nanotechnology and nanomaterials.

They stated:

> *".... although, insurers are more aware of the technology than the laypeople, this familiarity is still at a basic level. Given the fact that the insurance industry is one of the main bearers of the potential nanotechnology and nanomaterials risks, this suggests a need for more information transfer and exchange between the different stakeholders such as nanoscientists, regulators, nanotech companies and insurers themselves. This in turn could inspire the insurance market to move beyond the "wait and see" approach and encourage the adoption of different strategies to manage potential risks arising from nanomaterials production and use. For example, Mullins et al. (2013) propose a control banding (CB) approach that can be used by underwriters to assess the relative level of nanomaterials production risk. It can also form the basis for an underwriting decision-making process. Better risk communication and collaboration between the insurance market, nanoscientists, regulators as well as nanotech companies could also lead to the introduction of new insurance products. This, in turn, would directly contribute to the sustainability of nanotechnology and nanomaterials development and use."*

They also observed that insurance does not only compensate for losses, but it can incentivise nanotech companies to engage in more responsible practices in the production and use of nanomatierals.

They concluded:

> *"To avoid a situation where nanotechnology risks become uninsurable, the insurance market has to actively engage in risk communication with other main stakeholders in the field, as well as to adopt a number of precautionary risk management strategies. This is needed in order to manage the impact of possible adverse events that could threaten the ability of the nanotechnology sector to procure insurance, which ultimately could threaten the sustainability of nanotechnology development and use."*
>
> (http://xlgroup.com/~/media/fff/pdfs/insurance%20market%20perception%20of%20nanotechnology.pdf)(last visited 4/23/15).

So it is clear that there is potential for significant liabilities arising from the use of nanotechnology and that much more needs to be done by scientists, producers, users and insurers to understand, co-ordinate and manage the potential risk.

On the other hand it cannot be denied that not all feared emerging risks actually do emerge. Cellphone risk could be an example of one that has not materialized (or is it still too soon to tell?). Y2K was a very damp squib. What are the chances of nano risk fears being realized? That, of course, is a question that is difficult to answer given the lack of available research and knowledge of the risks involved. However, Charlie Kingdollar of Gen Re has pointed out that, if only 1% of the current (and increasing) 5,000 nanomaterials turns out to be toxic, that means that 50 new toxic substances will have been created. If 97% of nanomaterials are benign, that means 150 new toxic substances have been created. Furthermore, if 15% (and increasing) of manufactured goods involve the use of nanotechnology, then most of us are probably exposed to nano products in some shape or form. As we have seen with asbestos, pollution, agent orange and various other products' claims, the biggest insurance exposures often arise in the USA and have a tendency to end up reinsured in the London market. The potential is therefore clearly in the sights of both insurers and reinsurers.

The effects of asbestos and the way that the claims emerged to almost catastrophic effect on the insurance market, has of course made insurers more aware of the potential for such developments. Charlie Kingdollar of Gen Re, whilst powerfully drawing attention to the risks, the need for risk management and the potential for claims is reported by the Casualty Actuarial Society as saying (http://www.casact.org/press/index.cfm?fa=viewArticle&articleID=2294) that, *"by and large our industry is pretending this is something in the future, but it's already here. The question is "what we are doing about it" but I don't think*

there will be another asbestos. We move a whole lot faster than we did years ago". Hopefully, those words will prove to be prescient.