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Articles of General Interest

NANO-TOXICITY: A GROWING CONCERN

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ABSTRACT

There is a growing trend in the use of nanoparticles in various commodities due to their novel properties that have been recently exploited for commercial uses. As great as the achievement may sound but this also poses an important issue of its toxicity and the probability of it affecting the day to day life. It needs to be tackled and ripped in the budding stage. This paper talks about the uses of nanoparticles in general, their potential impact and the issues.

Keywords: Nano-toxicity, Nanotechnology, Nanoparticles, Toxicity

INTRODUCTION

There are various entities available in the market today that we use in our day to day life blissfully unaware off its ingredients and the composition. With the increasing demand of new novel properties, many companies are now shifting towards the increased use of nanoparticles in their products. Nanoparticles are extremely small particles, typically in the range of a hundred to a few nanometers ($1nm=10^{-9}m$). At this scale the fundamental property of the substance is greatly altered. In broad sense, the substance begins to show an entire new range of properties that are size dependent, tuneable and novel. (Poonam Takhar *et al*, 2011) At this scale, the size of the particle becomes so small that even the visible light cannot interact with it and hence these particles become virtually invisible even under an optical microscope. A lot of research is on-going in this field with the prima focus on the medical and electrical aspects. Over 800 products are already available in the market based on nanotechnology and several other are due to be rolled out (Poonam Takhar *et al*, 2011). New drugs for chronic state cancers and several other diseases based on nanoparticle formulation are being tested every day. The cosmetic industry takes the lead with extensive use of Zinc Oxide (ZnO) nanoparticles as the major ultraviolet radiation absorber. It is not surprising that Loreal leads in the field with the highest no of patents in nanotechnology. This is one aspect of the wonderful aspects of the novel nanotechnology. But what is greatly ignored is the darker side: the side of pollution.

With such novel properties at disposal, the nanoparticles pose a larger risk too. This is the risk of possible contamination. The contamination can be in all possible aspects, in all possible manners. There is a wild rush to exploit the potential benefits of nanotechnology but without the potential thought for any future based impact. What makes these nanoparticles a larger threat is that the exact mechanism by which they interact with the biological entities remains unknown. There have been many studies regarding the toxicity of these nanoparticles but most of them are in vivo.

TOXICITY: A MAJOR ISSUE

Till now we have been tacking various kinds of toxicity: water, air and land. Toxins in such states are usually in a gaseous or a liquid state. These toxins affect all forms of life on soil, air and water. There are toxins such as toxic gases, toxic chemicals that get dissolved in water and toxic chemicals. There are also suspended particulates such as that of dust, fly ash and other such industrial and commercial by products. These suspended matters have size in the micron range.

The mechanism by which these gaseous and liquid pollutants affect the life-form is extensively studies. Consequently sufficient measures are being taken to mitigate the adverse effects of such pollutants. The suspended particulate matter levels are usually kept in check so as to avoid any hazardous situation. This cannot be the case with the nanotechnology based pollutants. These pollutants are so small that they can easily pass

through the biological protection membranes. This poses a serious threat. The human body has evolved to mitigate the various pollutants that were there in the micron size. These pollutants are either not allowed to pass through the protection membranes in the body like the cells or are easily detected by the immune system. The nanoparticle based pollutants can be as small as 1nm. Such small systems are barely detected. It's only after an aggregation of these particles that they acquire a size enough to trigger an immune response. Little is known about their possible mechanisms of action. Many of them induce an apoptosis using the FAS activated pathways. For example, silver nanoparticles while other may induce cancer due to disruption in the signalling processes. As mentioned, the studies done so far are only in vivo and need a better understanding on a larger scale.

SOURCES

Sources can be many, depending on the type of compound. Copper nanoparticles are actively used as additive in lubricants, for metallic coatings and highly reactive catalysts in organic hydrogen reactions. ZnO nanoparticles are extensively used in the cosmetic industry as the ultraviolet radiation absorber. The operation of industries generates a no of particulates matter. Earlier they were confined to the micron sized particles but now with modified techniques a lot of nanoparticles are being released in the atmosphere along with the smoke. Due to their small size the gravity based separation methods fail, which work for most micron sized particles. The type of particles varies from industry to industry.

The dye industry, the textile industry and especially the semiconductor manufacturing or processing industries generate a lot of nanoparticles in the effluents discharged by them. The combustion of fuels in the engines generates nanoparticles as the fuels have additives that supplement the fuel. Example, lead particles were added to petrol and diesel as an anti-knocking agent but due to their detrimental effect on environment, they were banned. Volcanic eruption is a natural source of such nanoparticles. The extent of use may be relatively small but the impacts in the coming years is expected to be a major one (Lei *et al*., 2008). The nanoparticles may be ingested or may be inhaled. It depends on the occurrence of the nanoparticles or may even enter through skin contact as they as so small in size that they can easily move through skin pores.

REASONS FOR TOXICITY

The reasons for toxicity are varied and obvious. The surface to volume ratio of nanoparticles is exceptionally high hence physical and chemical behaviour is greatly modified. Some of the common reasons are included in the figure below:

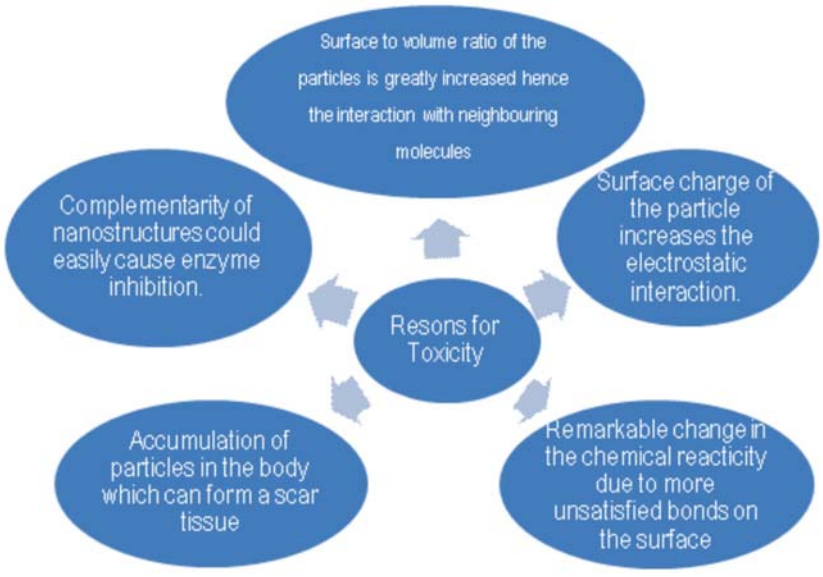

Fig.1: The main reasons for toxicity of nanoparticles (Poonam Takhar *et al*, 2011).

Among these effects, the most prominent is the accumulation of these nanoparticles that is the main cause of the toxicity.

EFFECTS & CAUSES

The effects are varied. But one thing that most nanoparticles have in common is that they are toxic, toxic in their raw form at varied concentrations. No doubt nanoparticles are used in our day to day products, but the concentration they are used in really low levels to cause harm or the harm is due to some prolonged exposure. Taking the examples of medicine, the concentrations are typically as low as a few micrograms and their circulation is highly regulated. In a nanomedicine the elimination of the drug from the body is as important as the process of targeting it at the specified site. Even in the consumer electronics, the disposal of these compounds is now being included in the product life cycle. But due to the growing use of such nanotechnology based products the concentrations are becoming really high.

Silver nanoparticles have been demonstrated to introduce FAS mediated apoptosis in cells. Alternatively they intercalate with the DNA and disrupt it. Nanoparticles from various sources have been shown to cause inflammatory and cardiovascular problems (Seaton *et al*.,2005*).* The nanoparticles get accumulated in the lungs on inhalation and are then route to the liver where they get accumulated. The ingested nanoparticles are accumulated in the kidneys. Copper nanoparticles on ingestion have been shown to induce drowsiness and anorexia in early stages as well as disruption of the epithelial lining of the gastrointestinal track, hepatocellular necrosis and acute tubular necrosis in the kidney (R. Lei *et al*., 2008). Zinc oxide nanoparticles if inhaled can cause Cytotoxic, genotoxic and pro-inflammatory effects on the human nasal mucosal cells.

CONCLUSION

The nanoparticles are a boon to the society if handled carefully. The promises that they have at hand are incomparable and so are the dangers. There needs to be proper regulation on their use. Separate government agencies are required to monitor the changes in the environment and the do further research in this area. The US Environmental Agency has already voiced its concern over the use of nanoparticles in several consumer goods already in the market (I. Linkov et al., 2008) Most of the studies done are in vivo. Onsite studies barely have a fair percentage. With the growing need, there is an essential need to tap into the potential of nanotechnology for the development of the society but there an equal need to regulate it. The problem with most of the issues is that they are ignored till the situation becomes chronic. It is better to take a cautionary step than to repent later. The nanotechnology based industry requires metric tonnes of nanoparticles every year and the demand is growing exponentially. It's better to wake up now.

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