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NANOTECHNOLOGY - UNPREDICTABLE RISK FOR ENVIRONMENT, HEALTH AND SAFETY

Abstract: Rapid development of nanotechnology requires from scientists, manufacturers, politicians and users comprehension of all nanomaterials properties. They should pay attention not only to production but also to other phases of product environmental lifecycle as the processes of its exploitation, utilization and recycling. We are not able to predict all long-term hazards of current nanomaterials application posing threats and unpredictable risks for ecology and health and safety. This means that we will need completely new habits for safe use and technologies for recycling and utilization of those materials and products.

1. Introduction

Nano is the word for atoms, dots, tubes, molecules, macromolecules, quantum wires and macromolecular aggregates. Improvement in laboratory equipment used in research into properties of nanomaterials i.e. scanning tunneling microscope (STM), atomic force microscope (AFM), high resolution transmition electron microscopy (HRTEM) are the milestones of the evolution of nanotechnology. New instrumentation for testing the properties of matter at the nanoscale directly and indirectly stimulating effect on the whole range of sectors of the industry. Also development of advanced “bottom-up” and “top-down” production processes contributes to expansion of nanotechnology. Significant improvement of engineering materials’ properties thanks to use of nanotechnology will gain new unpredictable applications for new materials and products. Nanosolutions are used for improving functionality of many materials and devices. Nanotechnology allows change of technology and promotes progress in many branches. In future thanks to achievements of nanotechnology, many materials will be modified for use in new applications and under extreme conditions. Nanotechnology is a part of many sectors of science, technology and everyday life, as it can be applied in many branches for example:

- chemical industry,
- material engineering,

– bioengineering and tissue engineering, genetic engineering,
– medicine, cosmetics, nanobiotechnology and pharmaceutical industry,
– defense and security,
– optical engineering,
– electronic industry,
– food and packaging industry,
– construction and architecture,

We can find nanosolutions in many products for example: nanodevices, nanocomposites, biosensors, nanotesters, nanopowders, membranes, molecular electronic devices, electronic components, laser components, plasma optical fibers, nano-additives to concrete, breakfast bags with nanosilver particles, cleaners and disinfectants (with nanosilver), polymers, ceramics and other materials, intelligent textiles, implants, drug carriers, cells in tissue engineering, sports equipment, hydrophilic glass, self cleaning glass, medical dressings, medication [1-3].

2. Environment and occupational safety and health

Nanotechnology has become a field of science that has developed in short time in an uncontrolled manner. Unfortunately, nobody is able to determine the long term effects of its implementation. Nanotechnology has impact on the environment, occupational safety and health. It should be noted that most of those materials do not exist in the natural environment, and their production requires new technologies, manufacturing techniques, wide range of chemicals and sophisticated equipment.

Over the years intensive industrial development and low environmental standards caused penetration to the natural environment by large amounts of compounds and chemicals for example from landfills. New produced synthetic nano-waste does not disappear, they remain present and can cause by mutual influence of various elements uncontrolled formation of new "products": compounds not present in nature or mutations of various microorganisms. The scale of this processes and its impact on our life is difficult to predict. Development of nanotechnology and increase of public awareness forces scientists and manufacturers to take these aspets under concideration. A wide range of nanotechnology applications and lack of comprehensive knowledge on social and health consequences of its use made politicians in many countries to take steps to prepare the relevant provisions regulating the development of new, advanced technologies. The United States Congress passed a law called The Nanotechnology Research and Development Act, which provides legal basis for the coordination of activities aimed at the nanotechnology development. The act defines a formal framework for discussion on nanotechnology and its impact on society. In addition nation-wide institutions were established whose activity are coordinated by the government, such as: The National Nanotechnology Coordination Office and the Environmental Protection Agency. The purpose of these institutions is to inform the public about the potential risks arising from the use of nanotechnology, as well as coordinating the work of research institutions and industrial activities [3-5].

Commercial processing of nanomaterials carries the risk of formation of nanowaste during manufacturing and processing of products and often during their lifetime. Preparation of nanoparticles is often associated with formation of undesirable waste of the nanometric size. Due to a variety of nanomaterials we do not have the technology to recycle most of them.

Many researchers and manufacturers focus on the nanoparticles production forgetting about byproducts and the potential long-term reactivity of nanoparticles with other substances existing in the technological process or in the natural environment. It should be noted that the nanoparticles due to the size and surface area are the substances which even a small amount can contaminate a large area. Therefore special procedures should be implemented for their classification, identification, utilization, recycling or storage. In order to organize the nanowaste classification we need to know the origin of the waste, their characteristics, environmental harm and the size of their production. It is not without significance that there is an impact of nanoparticles on living organisms, including humans. The long-term impact on workers can be revealed years later. Because of the way the absorption of various chemicals present in the nanoscale, their accumulation in the human body is still unexplored. It is therefore difficult to predict and classify possible occupational diseases related to exposure to nano factors in the work environment [3-6].

The classification of the nanowaste should be based on their physicochemical character, biological, technological and economical criteria e.g.:

- chemical composition,
- the industrial suitability for use,
- state of matter aggregation,
- toxicity,
- the degree of risk to the environment.

Rational development of nanotechnology has to prevent nanowaste creation and reduce the amount of waste and its environmental impact in the manufacturing of products, during and after their use.

3. The nanosilver - risk for environment, health and safety

Nanoparticles of the silver are commonly used in e.g. textiles, food packaging, cleaning products, electronic devices and bioapplications, although a better understanding of their environmental impact, toxicity and biological interactions is needed. The silver has been called “the natural antibiotic” for a long time but scientists proved that nanosilver have far more potential bactericidal and fungicidal abilities than silver, it is considered that have impact for many different microorganisms. Currently many of the commonly used medicine, dietary supplements, chemical cleaning and other products contains nanoparticles of silver. The commonly used water-based cleaning products with particles of silver show permanent antibacterial, antifungal properties of substrate. The bactericidal properties increase in proportion with the reduction in particle size. Aqueous solutions containing metallic silver nanoparticles are one of the newest disinfection measures. In 1 cm^3 of the solution at concentration of 1 ppm is 600 trillion particles of nanosilver. It should be noted that this nanoparticles after use remain in the environment and become a nanowaste causing risk for nature, health and safety [4,6,7].

Thanks the research [9] on the NPs is already known, that particles of nanosilver have the ability to pass through cell walls and interact with DNA. Research has shown that reactivity of nanosilver particles increases with decreasing their size. It was also shown the cytotoxicity of the nanosilver with respect to murine macrophages. It was assessed in vitro that the first nano-silver particles accumulate in these cells. Therefore it is important to explore and

determine the toxicity of nano-sized particles of metals, polymers, ceramics in terms of their interactions with cellular receptors, extra-intracellular, proteins, organelles and DNA [6,7].

The research conducted at Silesian University of Technology by Division of Nanocrystalline and Functional Materials and Sustainable Proecological Technologies shown that using of cleaning products with nanoparticles cause creations of areas with agglomerated particles of silver remaining after evaporation of liquid (Fig. 1) polluting the environment by nanowaste.

It should be a warning for scientists, politicians and manufacturers as it was in case of asbestos. We should never allow a situation in which the commonly used substance can affect the environment and human health and remain unrecognised causing catastrophic long-term effects.

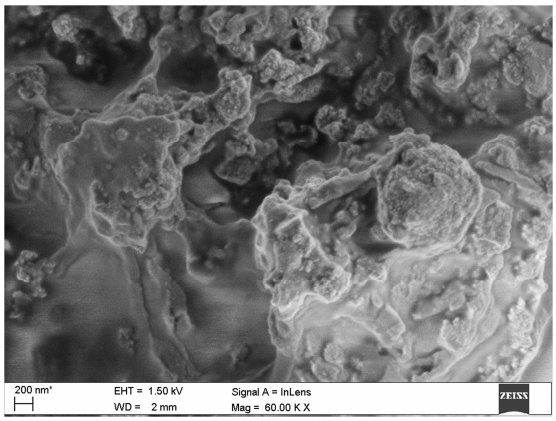

Fig. 1. Agglomerated particles of colloidal silver remaining after the evaporation of the cleaning liquid.

4. Conclusion

It should be remembered that besides many benefits of nanotechnology application there are a lot of unpredictable risks for environment, health and safety. Nanotechnology has an interdisciplinary character of research, gathers chemists, physicists, biologists, ecologists etc.. However it is no longer a domain of scientists only, because of a huge impact on us all. The society should be aware of all aspects of various nanotechnology solutions. People should be informed about advantages and disadvantages of nanotechnology applications. On the basis of this knowledge politicians should make decisions about legal solutions to reduce hazards and risk of new technology and quantity of nanowaste.

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