NANOMATERIALS AND SAFETY AT WORK

LjiljanaTrumbulović[1], Nataša Smiljanić[2], Marija Nikolić[2]
[1] College of Applied Studies Uzice, Sveti Sava Square 34, Uzice, Serbia,
[2] Medical school Užice,
(ljiljanatrumbulovic@gmail.com)

Abstract: *Nanotechnology is research and technology development at the atomic, molecular and macromolecular level in the range 1 – 100 nm size. For the next fifteen years it is that about two milion workers in the world be hired to support the production of nanotechnology. Nanomaterials are now used in electronics, biomedical, pharmaceutical, cosmetics, energy, etc.as a catalytic material. So far, not enough known possibile adverse effects of nanoparticles on human health. In no country there are no standars for MPC nanoparticles in the workplace.*
The aim of this paper is to increane safety in the work of employees handing nanomaterials, and reduc the risk of damage to health of employeees.

Key words: *nanomaterials, nanotechnology, health risk*

1. INTRODUCTION

Nanoparticles exist forever, but since the industrial revolution have dramatically increased exposure to nanoparticles. Natural sources of nanoparticles are volcanoes, fires, viruses, microparticles and nanoparticles antroogeni sources are: internal combustion engines, power plants and other sources of thermal decomposition, the design accurate particle size and feature-specific nanofibers and nanotubes).

According to the definition of nanotechnology is the development of technology and research on atomic, molecular, and macromolecular level in a size range of about 1 -100 nm (1 nm-10^{-9} m), so as to created and used by the structure, and means on the nanoscale systems having a new properties and functions because of their small or medium size.

Nanotechnology is today the most developed in the field of development of electronic circuits and other devices from single atoms and molecules. The primary task of nanotechnology production komjuterskih chips and other assets that are a thousand times smaller than the present. The nano include those having at least one dimension in the range of 1 - 100 nm. The nanoparticles have an enhanced biological activity that is desirable in applications in medicine, diagnostics, therapy, support the interpretation of molecular processes and structures in a living organism. The same properties of nanoparticles that make it desirable and can be harmful.

On the market today a large number of available materials and products which are obtained by using nano-technology such as powders, solutions and suspensions, as well as composite materials. Titanium dioxide nanodimension range is used as a filler in cosmetics, while silicon nanoparticles are used as fillers for various materials. A number of other new and improved products appeared on the market as, for example, textile materials, which does not mark or the absence of creeping, or fixed tennis balls of the composite material of butyl rubber and nanoclays. Nanocoatings nanocomposites and today we are using in many products, starting with the bike to the car.

Research and development in nanotechnology includes the handling and control structures at the nanoscale, and their integration into larger material components, systems and architectures. In larger ensembles control and construction of their structures and components remains at the nanometer level. In some special cases, the length of material may be less than 1 nm (manipulation with the atom to about 0.1 nm). These are polymers reinforced with nanoparticles, which have a size of about 200-300 nm, and which are functions of the local bridge or a bond with the polymer nanoparticle. For the next 15 years is predicted to be about two million workers in the world will be employed to support the production of nanotechnology.

Nanoparticles not yet well defined because some authors term ultrasitnih or very fine particles are classified all those less than 100 nm. Ultrafine particles (even less than 0.01 nm), are constantly present in the urban environment in the form of smoke from the combustion in the exhaust gas from the diesel engine and from various industrial processes, such as, for example, welding.

2. *NANOPRODUCTS*

Nanoproducts are made for two main reasons: to yield a large increase in surface area per unit weight and the effect of quantum phenomena. Catalytic processes and other chemical processes take place on the surface wherefore reduction of particles leads to increase of their reactivity. Since nanoparticles have large contact surfaces, nanocrystals of metal have great strength. So nanocrystalline nickel has a much higher strength than ordinary nickel and strong as the hardest steel.

Quantum phenomena are changing the optical, magnetic and electrical properties of nanoparticles and they are beginning to behave like waves. This gives them entirely new, useful properties. There are over 200 species of nanoproducts in the world today. The present commercial materials on the market are mostly nanoclay, nano-oxides and nanotubes. Nanoclay of zeolites used for various types of filters and various composite materials, for example, in polymers for packaging materials. One of the classification of nano products share them to: a thin coating nono fiber dimensions (fiber, wire and tube) and particles. The most important materials that are used today in nanotechnology are carbon tubes, titanium dioxide, silicon, germanium, materials based on calcium oxide, and particles coated plane proteins or DNA. Examples nanoproducts:

1. nano- crystals (1-10 nm) – semiconductors, , metals, magnetic materials;
2. other nanoparticles (mean diameter 1-100 nm) - oxide ceramic material;
3. nanoconductors (mean diameter 1-100 nm) - metal, semiconductor, oxides, sulfides, nitrites;
4. nanotubes (with a diameter of 1 -100 nm) - carbon - nanotubes.

Nanomaterials, because of its very good properties and new characteristics are used today in many industries - for use in electronics, such magnets in medicine, pharmacy, cosmetics, energy, as well as catalytic materials for other purposes. The current chips for personal computers are 65 nm, 90 nm and 130 nm. Soon they will be installed size of 45 nm. Great use is in the mechanical and chemical polishing materials, in the production of magnetic tape, the electrically conductive coating material, for optical fibers and others. Prototypes means for storing electronic data and have 100 times more storage density of today's commercial. The use of nanomaterials for solar cells on rooftops, which will provide energy for homes, for better quality shoes and others. Mention should be made use of these materials for various types of products, such as in the automotive industry - the thresholds for the car, paints and coatings that protect against corrosion, scratches, tires for cars with improved resistance to skidding and abrasion, staining the body and like other parts.

Nanoproducts are used for the production of protective coatings and coating the anti-glare on the glasses, the encapsulated inks for copiers, tools for cutting of metals, for the light and sturdy tennis racket, bedding that does not stain, binder material in dentistry, materials for covering wounds and burns, water filters. When glass is covered with a layer of titanium dioxide nanocrystals, they provide a large number of spikes on the smooth surface. Water that enters the glass can not be retained on the surface because the contact area then very small so that it does not wet glass. Reduces the contact area between the glass and dust, these particles can not retain water and it easily washes. Some detergents are added to silver nanoparticles that exhibit antibacterial and antifungal properties. Silver nanoparticles are added and the material for astronaut suits, since it can not be washed. They are made textile materials with nanoparticles that are not dirty.

Adding nanoparticles in concrete reduces the porosity of the concrete and the required amount of water for concrete production. After curing concrete that has a feature that stresses better distribution, and the concrete is fifteen times stronger than ordinary and does not need to be added reinforcement. When nanoparticles of cesium oxide added to diesel fuel, reducing harmful impact on the environment. These particles are related to contaminants in the fuel and reduce their thermal resistance and heat them during fuel combustion destroys. By addition of nano particles of the motor oil improves the lubrication of the engine, and therefore it will be prolonged life and reduces fuel consumption.

In medical use the nano particles will be used as means for transmitting and the release of drug substances in the body, including means which automatically determine the required level of drug for medical diagnostic agent, such as bookmarks malignant cells. Quantum dots have the characteristics of the semiconductor crystal, and can be excited by a laser, and so that fluoresceiraju, respectively, are illuminated.

There are ongoing projects or planned projects related to the way that with nanoparticles enter the target in the organism cytostatic agents which act on specific location (which may have very little toxic effects), and that the nanotubes in the form of fibers used to replace blood vessels in vascular surgery, i.e., surgery bay-pass, in order to improve the contrast characteristic of the radiology et al. Nanotechnology will allow for studying the physiological pathways in the body, and how the individual molecules in the cells. Titanium dioxide-nanodi of the dimensions used in the compositions for protection against sunlight, while the nanoparticles of silicon used for a dental filling.

3.TOXICOLOGY NANOMATERIALS

Toxicology of nanomaterials deals with harmful effects of nanomaterials on human health.It is believed that human exposure in the workplace to several hundred micrograms per cubic meter. With decreasing particle size increases its reactivity. The increase in reactivity could increase the adverse effects of the substance. Because of this nano technology can occur harmful substances from products that are in conventional form harmless. Nanoparticles have a relatively large surface area, which allows them to react to a greater extent with the environment and with other substances.

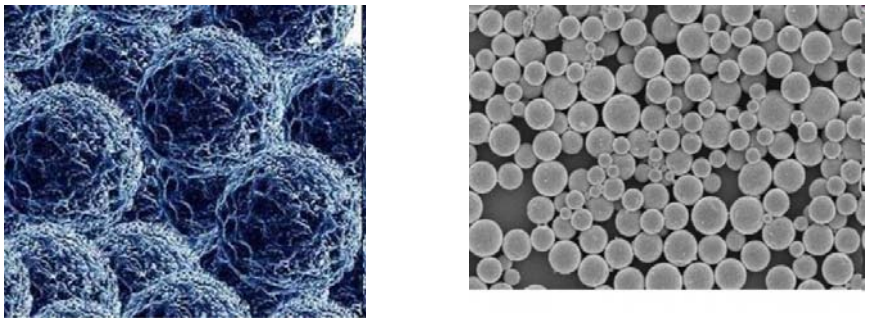
Previous research in animals suggests that nanoparticles are potentially harmful to living organisms and can cause damage, especially to the lungs, central nervous system and blood vessels. Ultrafine particles pose a greater risk to the bigger ones, because to a great extent caused by the inflammatory response in the lung tissue. It turned out that they have the ability to cross the blood brain barrier and thus show after-economic potential to give adverse effects to the central nervous system. In addition, the inhalation of nanoparticles increases the risk of death from heart disease. For example, ultra fine particles of $Ti0_2$ (20nm) caused a more intensive inflammation than the same dose of fine particles of $Ti0_2$ (250 nm).

Introduction of nanoparticles could be inhaled through the digestive organs or through the skin.Nanoparticles relatively easily pass the barrier of the surface layer of the skin, and blood-brain barrier.

Way through the respiratory system. It is known that the fraction of dust (particles less than 5 micrometers) due to inhalation to the lung alveoli. However, very small particles of dust, with a diameter less than 2 nm, and preferably from 0.1-0.2 nm carried by the air flow of the inhaled air once in the lung, or a large part of these particles, carried by the exhaled flow, back, so that the not retained in the lungs. A particle size of 1 nm, 90% of inhaled is retained in the nose section, and 10% in the trachea. Experimentally, it was shown that increasing the size of 5 - 20 nm increased representation in the alveoli, at 20 nm. Even 50%. Some studies show that nanoparticles are inhaled through the nasal mucosa, could enter the brain passageways blood-brain barrier.

Way through the digestive system. Nanoparticles can be entered by ingestion through drinking water, through food additives, atmospheric dust in food, through toothpaste (dental filling and implants). When they enter the digestive system, still being spread through the bloodstream. Nanoparticles can come directly into the digestive system through contaminated food, water, or if they are in cosmetics and drugs. Most research shows that they pass through the digestive system - about 98% and is excreted in the faeces and urine.

Way through the skin. Nano particles can enter the skin and continues to be blown through the bloodstream. The nanoparticles penetrate the skin more easily in places where the skin is thinner, the injured (wounds). The particles enter the lymphatics and lymph nodes, and through them penetrate into the blood. *Way through a blood vessel* depends on the chemical characteristics of the particles from the surface of the particles and their size.



Picture 1. – Penetration of nanoparticles depends on the particle size

So far, not enough to know the possible adverse effects of nanoparticles on human health. For these reasons, in the course of the research projects in the plan are a large number of research around the world relating to exposure, ways of introducing nanoparticles, transport, toxicity, transformation, biological cycle, and the biological effects of a mixture of particles.
Potential adverse effects of nanotechnology may be a result of the nature of the particles, the properties of the products containing such particles and processes of manufacture. The nanoparticles are characterized by high surface area, and the different crystal structure and the high reactivity, which may facilitate the effect of the living organism, and due to the small size of the interaction with the cell material and the transport into the working environment. Ultrafine particles, which have little solubility, are far more toxic than larger particles by total weight.

Studies on the workers who are exposed to an aerosol of the production of fine (microscopic) and the very fine particles (nanoparticles) show that among them deteriorates lung function and the occurrence of respiratory symptoms. For now there is not enough reliable evidence that there was an appearance of the disease in humans caused by nanoparticles, but it is very clear that this can happen.

Nanotechnology will enable the development of high-efficiency filter respirators, work clothes that will repel deposition of dust on it and the appearance of stains, materials that will be good sound insulators, those who are resistant to fire, protective screens for the prevention of falls from the roof, curtain control ventilation in mines, catalysts to reduce emissions of toxic substances and means for facilitating the removal of pollutants in the workplace. Sensors based on nanotech materials and communication tools will be enabled to better respond to emergencies and reduce the risk of injury. Fuel cells, precision analyzers and the optoelectronic means, the resulting nanotechnology methods, have great potential also linked to health and safety at work.

A large surface area increases the reactivity of the nanoparticles so that it can be assumed that there will be a risk of dust clouds of nanoparticles of substances that normally are not explosive (as in a coal dust or the dust in a silo) when the nanoparticles are to be occurred in a certain concentration in the air.

Although there is no information relating to the prediction of occurrence of fire and explosion associated with nano powder substances, it can be considered that the inflammable materials on the nanoscale can pose a greater risk than the same materials in the form of larger particles of the similar mass concentration in the air. Some nanomaterials may initiate catalytic reactions as opposed to the same chemicals in a different form.

The risk of exposure employed nanoparticles exist in the making of the composite nanomaterial to, coating the material with nano-particles, or in the production of nanostructures, such as integrated circuits.

Persons in the following occupations may be to a greater extent, be exposed to nanoparticles:
- Work on the production of nanoparticles in the gas phase in a system that is not closed because it increases the release of aerosols in the work environment;
- Use of nanomaterials in the production in the form of a powder or solution, and the suspension has a higher risk for the release of the nanoparticles in the working environment;
- Maintenance System for the production, including the clean up and discharging the material from a dust collection system, may result in a greater exposure of the nanotube-particles by inhalation such as by raising the precipitated nano-material;
-Working with the nanomaterial in a liquid medium without an adequate Personal Protection (without protective sleeve ica) as this may cause dermal absorption;
- Working with the nanomaterial in the liquid during the operation of stirring, refilling or the process where the mixture is treated with the simultaneous mechanical processes (mixing, blending, centrifuging and the like.), because then the respirable droplets are formed;
- Work on the handling of nanostructured powders leads to aerosolization opportunities in the workplace;
-Cleaning spills or waste nanomaterials in production represents a potential risk for workers who perform these tasks;
-Mechanical treatment of a material containing nanoparticles - grinding, drilling, milling, cutting and similar procedures increase the likelihood of aerosol in the air.

4. PROTECTIVE MEASURES

Dry nanoparticles are considered to be far more toxic than wet. Thin films of nanomaterials are considered to be more secure in terms of ingestion and the impact on the environment because it does not release easily from the surface to which they apply. They can apply the following safety measures:

Technical protection measures

- Isolation source of creating nanoparticles and local suction ventilation at the site of pollution that can effectively remove nanoparticles with high efficiency filter on the final part of the ventilation to be collected nanoparticles would not spread to the environment.
- Good working practice involves cleaning workspaces vacuum cleaner with a filter, wipe damp surface early, a ban on the consumption of food and beverages in the workplace and bezbeđivanje favorable conditions for hand washing, showering and implementation of working clothes after work.

Means of personal protection

For now there are no instructions for suits and gloves for personal protection should be used to prevent the penetration of nanoparticles through the skin. It should be noted that some standards for protective clothing include the testing of nanoparticles.

The use of respirators is necessary when mechanical or administrative protective measures can not provide effective control of exposure to nanoparticles in the workplace. There are only prescribed maximum permissible concentration in working environment for the larger particles of the same chemical composition, but not for the nanoparticles. Preliminary findings suggest that the medium respiratory filter should be one of the classic fiber particle size of 2.5 nm.

This assumption gives such a filter to protect workers from inhaling nanoparticles, has yet to gain scientific confirmation. A number of types of nanoparticles are produced in a vacuum, which can eliminate the need to wear a respirator.

Health control

Have not yet been adopted, the recommendations relating to the monitoring of workers' health, which are in the working environment exposed to nanoparticles, ie, the content of the periodic medical examination.

5. CONCLUSION

Very small particles and nanoparticles as contaminants in the working environment causing adverse effects. Inhaled nanoparticles can be a trigger for inflammation in the lungs. When nanoparticles have entered the secondary target organ, such as the cardiovascular system, the brain, can also initiate an inflammatory process in a tissue. The lack of toxicological data on nanoparticles prevents accurate assessment of the risks from the use of the same.

The American Heart Association (American Heart Association) expressed the view that exposure of nanoparticles in the air are a potentially higher risk of death from heart disease.

So far it is not known what are the possible consequences of long-term exposure to nanoparticles in the workplace and their absorption and what will be the impact on biological organisms, the occurrence of pollution nanoparticles in the environment, which is the subject of future research.

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