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NANOPARTICLES IN THE AIR OF THE WORKING ZONE AS A RISK FACTOR FOR THE HEALTH OF WORKERS OF VARIOUS INDUSTRIES

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Ключові слова: наночастинки, дрібнодисперсні фракції, повітря робочої зони, професійний ризик

Ключевые слова: наночастицы, мелкодисперсные фракции пыли, воздух рабочей зоны, профессиональный риск

Abstract. Nanoparticles in the air of the working zone as a risk factor for the health of workers of various industries. Sevalnev A.I., Sharavara L.P., Kutsak A.V., Nefodov O.O., Zemliynyi O.A., Pisarevskyi K.I., Shevchenko O.S.

Purpose: analysis of scientific literature, summarizing data on domestic and foreign experience of assessing the determination of nanoparticles in the air of the working zone as a risk factor for the health of workers of various industries. The article analyzes the literature data on the study of the content of fine dust and nanoparticles in the atmospheric air and air of the working zone of different industries. Numerous studies indicate that fine dust is contained in the emissions of many industrial enterprises. According to the World Health Organization by level of impact on human health, suspended particles in the air and especially in the air of the working zone belong to the priority pollutants. Evaluation of the dust content in the air of large industrial cities is particularly relevant, because of a large number of sources of dust emissions of various origins in urban areas. Various technological processes contribute to the formation of fine dust and nanoparticles which pollute the ambient air and the air of the working zone. Data on the negative impact of fine dust and nanoparticles on health of workers are presented. Attention is paid to the problem of hygienic assessment of nanoscale dust content in the working zone air. The obtained results indicate that today the issues of studying the physicochemical properties of nanoparticles, their toxicity to the body, analysis of potential risks to humans, the development of an effective and reliable system for monitoring ultrafine particles in the environment and the production environment are still relevant as for informing employees about the risks involved, reducing and preventing harmful effects on humans. The potential negative effects on workers' health determine the need and opportunity for further research in this area.

Реферат. Наночастинки в повітрі робочої зони як фактор ризику для здоров'я працюючих у різних галузях виробництва. Севальнєв А.І., Шаравара Л.П., Куцак А.В., Нефьодов О.О., Земляний О.А., Писаревський К.І., Шевченко О.С. *Мета роботи:* аналіз наукової літератури для узагальнення даних про вітчизняний і зарубіжний досвід оцінки визначення наночастинок у повітрі робочої зони як фактора ризику для здоров'я працівників різних галузей виробництва. У статті проведено аналіз літературних даних щодо дослідження

вмісту дрібнодисперсного пилу та наночастинок в атмосферному повітрі та повітрі робочої зони різних галузей виробництва. Численні дослідження свідчать про те, що дрібнодисперсний пил міститься у викидах багатьох промислових підприємств. За рівнем впливу на здоров'я людини зважені частинки в атмосферному повітрі й особливо в повітрі робочої зони Всесвітньою організацією охорони здоров'я відносяться до пріоритетних забруднювачів. Особливо актуальна оцінка вмісту пилу в повітрі великих промислових міст, оскільки на урбанізованих територіях знаходиться велика кількість джерел пилових викидів різного походження. Різноманітні технологічні процеси сприяють утворенню дрібнодисперсного пилу і наночастинок, які забруднюють атмосферне повітря та повітря робочої зони. Приводяться дані щодо негативного впливу дрібнодисперсного пилу та наночастинок на здоров'я людини та працюючих. Приділено увагу проблемі гігієнічної оцінки вмісту пилу нанорозмірного діапазону в повітрі робочої зони. Одержані результати свідчать про те, що на сьогодні все ж таки залишаються актуальними питання вивчення фізико-хімічних властивостей наночастинок, їх токсичності для організму, аналізу потенційних ризиків для людини, розробки ефективної та достовірної системи моніторингу ультродисперсних частинок у навколишньому та виробничому середовищі, обов'язкового інформування працюючих про наявні ризики, зменшення та профілактику шкідливого впливу на людину. Можливі негативні наслідки для здоров'я працюючих зумовлюють необхідність і доцільність подальших досліджень у цій галузі.

Today, one of the leading directions in the development of world technological progress is work on the use of nanotechnology in industry and the creation of promising nanomaterials. In this regard, a large number of materials appear in different industries, which in their composition have particles of the nanoscale range (less than 100 nm). Nanotechnology has not only obvious advantages, but also carries a potential danger to human health and the environment. The use of nanotechnology and the emergence of new nanomaterials in industry require a detailed assessment of the potential risks associated with their use. The study of occupational risks in contact with humans and biological objects of the environment with nanoparticles is an urgent and important task of occupational medicine today.

Purpose: to analyze the scientific literature, to summarize data on domestic and foreign experience in assessing the determination of nanoparticles in the air of the working zone as a risk factor for the health of workers in various industries.

According to the World Health Organization by the level of impact on human health, suspended particles in the air and especially in the air of the working zone belong to the priority pollutants. The undoubted danger to human health is represented by particles of the PM₁₀ and PM_{2,5} fraction, which have the ability to penetrate the thoracic section of the respiratory system and cause a negative effect on human health. The presence of nanoparticles in the atmospheric air of populated areas and in the air of the working zone of various industries is proved by the data of domestic and foreign studies [4, 5, 15, 21, 25, 27, 40]. Numerous studies have proved the negative effect of dust on human health [7, 34, 37, 39, 44], especially on the cardiovascular system [13, 29, 30, 38, 43], respiratory system [2, 21, 33, 42, 43], contributing to the increase in mortality from cardiovascular and respiratory diseases, lung cancer [1, 8, 13].

According to research of scientists from different countries, suspended particles formed as a result of motor vehicles emission, cause an increase in mortality by 6% among different population groups and increase the total amount of cases of chronic bronchitis and asthma attacks in adults and children as well.

Evaluation of the dust content in the air of large industrial cities is particularly relevant, because of a large number of sources of dust emissions of various origins in urban areas: the operation of automobile engines, the movement of cars along the roads, the burning of solid fuels, and various industrial enterprises.

Numerous studies indicate that dust is contained in the emissions of many industrial enterprises: of ferrous and non-ferrous metallurgy, construction, mechanical engineering, electrical engineering. Technological processes at these industrial enterprises result in the formation of fine dust [3, 18, 16, 19, 21, 22, 27, 41] and, accordingly, the formation of particles of the nanoscale range is possible.

The technological processes of crushing, grinding, mixing, storage and transportation of bulk materials, melting contribute to the formation of fine dust and dust with an aerodynamic size of less than 10 microns, which are not captured by dust cleaning plants and contribute to the pollution of atmospheric air and air of the working area with solid particles of different sizes, including ultrafine [14, 18, 17, 23, 35].

The concentrations of suspended particles in the air of the working zone are much higher than the concentrations of these particles in the atmospheric air due to the close proximity to the source of formation and the use of processes of solid materials processing. Depending on the mechanisms of formation, aerosols of disintegration, formed as a result of processing of solid materials (cutting, crushing, grinding, grinding, etc.), and condensation aerosols, formed as a result of cooling of vapors (melting, welding of metal) are distinguished.

Numerous studies indicate that nanoparticles cause a negative effect on the worker's health and can cause changes in the human body, in particular, changes in the immune system [36], development of cancer [40], they affect the respiratory system [31], cause diseases of the cardiovascular system and increase the risk of mortality from coronary heart disease [28, 32], increase the incidence of the urogenital and digestive system diseases, affect the central nervous system, cause diseases of locomotor apparatus [16, 38].

Unfortunately, nowadays, the hygienic assessment of dust content in the air of the working zone does not reflect such characteristics of dust as the particle size, their shape, surface area, the number of particles; this does not allow to fully determine the amount of potential risk to human health

Today, in Ukraine and worldwide, there are no values of maximum permissible concentrations (MPC) for nanoscale particles of different chemical composition, which is a serious problem in the assessment of the level of occupational risk [12, 33]. In the case of hygienic assessment of the level of exposure of nanoparticles in the air, foreign scientists propose to use "test levels", namely for metals and biologically stable dispersed nanoparticles with a density of $>6000 \text{ kg/m}^3$, the quantitative concentration of particles in the range 1–100 nm should not contain more than 20 000 particles/cm³, for biologically stable dispersed nanoparticles with a density of $<6000 \text{ kg/m}^3$ – more than 40 000 particles/cm³. However, for some nanomaterials, there are maximum allowable concentrations determined by leading experts of the US Institute of Occupational Health and Safety (TiO₂ – 0,3 mg/m³, carbon nanotubes and nanofibers – 0,007 mg/m³), and for other substances it is recommended to use safety factors recommended by British Institute for Standards for Risk Assessment [11, 12].

Today different scientists worldwide actively conduct research of influence of nanoparticles on the state of health of humans [34] and determination of their presence in the air of the working zone. So, by the group of scientists content of nanoparticles in the air of the working zone of workers, at a receipt and production of nanoparticles of different chemical composition for industry was investigated. As a result of the study, it was found that the available concentrations of nanoparticles in the air of the working zone can exceed the calculated MPC according to safety factors for nanomaterials, even if there is no excess of the existing MPC for these substances in the usual form. Also, the results of the study indicate the presence of a background concentration of nanoparticles before work and the

presence of other chemical elements not related to the process; this may be a consequence of internal and external factors, that also increases the level of risk for workers [9, 10, 16, 20, 24, 26].

According to the research, of Varivonchik D.V. and others a hygienic assessment of the working conditions of dentists and dental technicians was carried out as a result of which it was established that they are exposed to dust of the nanoscale range of about 14 metals that make up the materials they work with. The recommended standards for nanodispersed dust of II-III hazard classes were exceeded by 4,8 times according to the Hygienic classification of working conditions [5, 6].

According to the results of studies of Movchan N.A. et al. at the Institute of Occupational Medicine of the Academy of Medical Sciences, it was found that lead has a high level of emissions of the nanoparticles of this element into the air of the working zone. Almost 90 % of all sizes have sizes from 1 to 100 nm, and their values in fractions of 5–10 nm, 10–15 nm and 15–20 nm, the development and implementation of preventive measures are required to improve the working conditions of workers. area [15].

A large number of studies, which confirm the presence of nanoparticles in the air of the working zone of various industries and possible negative consequences for the health of workers, necessitates the expediency of their research, namely, the physicochemical and toxicological properties of nanoparticles of various chemical composition, their effect on the human body and the development of scientific justification of the hygienic standard of these substances in the air of the working area.

CONCLUSIONS

1. Numerous studies of scientists indicate that fine dust is contained in the emissions of many industrial enterprises. Various technological processes contribute to the formation of fine dust and nanoparticles, which pollute the ambient air and the air of the working zone.

2. According to the World Health Organization by the level of impact on human health, suspended particles in the air and especially in the air of the working zone belong to the priority pollutants. Numerous studies indicate that nanoparticles cause a negative effect on the worker's health and can cause changes in the human body, in particular, changes in the immune system, development of cancer, they affect the respiratory system, cause diseases of the cardiovascular system and increase the risk of mortality from coronary heart disease, increase the incidence of the urogenital and digestive system diseases, affect the central nervous system, cause diseases of locomotors apparatus.

3. Analysis of literary sources suggests that today the priority scientific, research in the field of nanoparticles including medical, should be considered:

- the study of the physicochemical properties of nanoparticles, their toxicity to the body;
- analysis of potential risks for humans, the development of an effective and reliable system for

controlling ultrafine particles in the surrounding and production environment;

- development of a system for mandatory informing employees about existing risks in order to reduce and prevent harmful effects on humans.

Conflict of interests. The authors declare no conflict of interest.

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