

INFLUENCE WORKING CONDITIONS AND WORKERS SKILL LEVELS OF STRESS IN NANOTECHNOLOGY

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ABSTRACT: Activity in the nanomaterials domain involves some risks of toxicity caused by the characteristics of the materials. The characteristics that generate most of the risks are: particle dimensions, surface state, electronic, optical and magnetic proprieties, content of toxic metals. Also, the involvement in many catalytic and oxidative reactions could cause toxicity. Important risks could be generated by the means of the change in the physicochemical and structural properties during engineering nanaomaterials. Specialists are aware of most of these risks but not of all of them. On the other hand, current equipment does not allow the identification and complete evaluation of the nanomaterials toxicity. Based on these considerations this paper aims to assess the stress caused by applying the psychological experiment method at work in various fields of nanomaterials, referring to occupational exposure. The main objective is improvement of safe and healthy work conditions, based on experts' knowledge.
KEY WORDS: stress evaluation, nanomaterials, psychological experiment, questionnaire

1. INTRODUCTION

Since nanotechnology was introduced by Nobel laureate Richard P. Feynman during his now famous 1959 lecture "*There's Plenty of Room at the Bottom*," [1] there have been many revolutionary developments in physics, chemistry, and biology that have demonstrated Feynman's ideas of manipulating matter at an extremely small scale, the level of molecules and atoms, i.e., the nanoscale. Every person has been exposed to nanometer-sized foreign particles. We inhale them with every breath, and consume them with every drink [2]. This exposure can be divided into three wide categories: occupational exposure, consumer exposure and environmental exposure. Exposure of nanotechnology workers and consumers using nanoparticle containing products are near time concern, which needs immediate attention [3]. With the increasing demand of nanomaterial in the market the exposure of workers making these materials and using nanoparticles in the manufacturing plant is increasing occupational exposure is due to constant involvement of the person with nanomaterial manufacturing and research [3]. Nanomaterials represent new substances that require analysis health and stress evaluation, research and testing to determine wheter they pose health or stress risks or other type of risk and how those risks can be managed [3]. A series of scientific reports have highlighted persistent scientific uncertainties and knowledge gaps regarding environmental and health impacts, most notably the 2004 report on nanosciences and nanotechnologies by the UK's Royal Society and Royal Academy of Engineering [5] The need for risk assessment of ENM has generated also a need for a novel risk assessment concept. Even though the key-steps of risk assessment, notably hazard identification, hazard characterization and exposure assessment followed by risk characterization, in an optimal case leading to quantitative risk assessment remains the cornerstone of assessment of safety of ENM, special features of ENM require modifications to the current procedures. [9] Published studies on the toxicological and ecotoxicological effects of nanomaterials are frequently the subject of intensive discussion in which experts also express conflicting views.

2. EXPERIMENTAL SECTION

2.1 Psychological experiment

Widely used in experimental research is dimensional analysis method, random balance method, full factorial experiments methods, methods which themselves require a large amount of data processing. For the organizing and conducting the psychological experiment the coordinator investigation, based on the previous experiences, establish which are the parameters (independent factors- input values)and performance indicators (objective functions- output values) followed, compose survey questionnaires and choose the specialists which will be consult. The specialists are required to rank the factors of the process taking into consideration the influence they exert on performance indicators, given one rank to each factor and the first ranks will be assigned to the most important factors. It can be mentioned that in case of these factors cannot be ranked, much more parameters can receive the same rank. This paper aims to assess the stress caused by applying the psychological experiment method at work. For this purpose, a questionnaire for stress caused by toxicity assessment was prepared and completed by experts with answers.

Influence working conditions and workers' skill levels of stress in nanotechnology generating causes were identified health risk and safety, giving a weight to grades 1 to 6.

Table 1 Influence proposed for classification

Factor	Description	Rank
X_1	work equipment	
X_2	effective exposure	
X_3	lack of lack of preventive actions	
X_4	clear misundestending of nanotoxicity	
X_5	lack of social support from colleagues	
X_6	stress	

Nanotechnology is considered by many as the next logical step in science, integrating engineering with biology, chemistry and physics . [8]

3. RESULTS AND DISCUSSION

In the second stage, where many parameters have received the same degree of influence, correction is considering real place in the string parameter ordering. [7] The analysis results in Table 2 can be seen that the hierarchy of factors has not changed. Thus, the correlation coefficient between primary and secondary data table is rs = 1.

In Table 3 are presented corrected values, new scores for each parameter and the new order of influence.

To show that the tables are equivalent is calculated r_s between Table 2 and Table 3 and between 3 and 4.

Checking adequacy primary data set with data from the secondary table (corrected) is based on correlation coefficient Rs, which is: [7]

Table 2. Primary ranking factors influence

Experts	Influence factors					
	X_1	X_2	X_3	X_4	X_5	X_6
1	5	3	4	1	2	6
2	5	3	4	1	2	6
3	5	3	4	1	2	6
4	5	3	4	1	2	6
5	4	1	2	3	5	6
6	6	2	3	1	5	4
7	6	2	3	1	5	4
8	3	3	1	2	3	3
9	5	1	4	3	2	6
10	5	3	4	2	1	6
11	4	2	3	1	6	5
12	3	1	2	4	5	6
13	3	1	2	4	5	6
14	5	3	4	1	2	6
15	2	1	3	5	4	6
The amount A_j	66	32	47	31	51	82
$Q_{(1)}$	5	1	3	2	4	6

$$r_s = 1 - \frac{6}{k^3 - k} \sum_{j=1}^{k} \left[Q_{j(1)} - Q_{j(2)} \right]^2 \quad (1)$$

Table 3 Table correction of ranking factors influence

Experts	Influence factors					
	X_1	X_2	X_3	X_4	X_5	X_6
1	5	3	4	1	2	6
2	5	3	4	1	2	6
3	5	3	4	1	2	6
4	5	3	4	1	2	6
5	4	1	2	3	5	6
6	6	2	3	1	5	4
7	6	2	3	1	5	4
8	4	4	1	2	4	4
9	5	1	4	3	2	6
10	5	3	4	2	1	6
11	4	2	3	1	6	5
12	3	1	2	4	5	6
13	3	1	2	4	5	6
14	5	3	4	1	2	6
15	2	1	3	5	4	6
Tte amount A_j	67.5	33.5	47	31	52.5	83.5
$Q_{(1)}$	5	1	3	2	4	6

where k = number of influencing factors (x) = 6

rs = 1 (2-3)
rs =0.97 (3-4)

If the value of rs is close to 1, the results (ranking) side table consistent with those of the primary table. If rs = 0, then there is concordance between the results of two tables, and if rs = -1, the results of the two tables are contradictory. Because no consistent results between continued processing will be done only with secondary table. The next step is weighted proportional to the opinions of specialists training, experience in the studied seriousness and interest in the investigation. Paying a score like that in the first stage, but this time specialists.

Table 4 Weighted experts opinions

Experts	Influence factors					
	X_1	X_2	X_3	X_4	X_5	X_6
1	7.75	4.65	6.2	1.55	3.1	9.3
2	8.4	5.04	6.72	1.68	3.36	10.08
3	9.8	5.88	7.84	1.96	3.92	11.76
4	6.65	3.99	5.32	1.33	2.66	7.98
5	6.52	1.63	3.26	4.89	8.15	9.78
6	9.3	3.1	4.65	1.55	7.75	6.2
7	7.89	2.66	3.99	1.33	6.65	5.32
8	2	4	9	9	9	9
9	7.4	1.48	5.92	4.44	2.96	8.88
10	7.4	4.44	5.92	2.96	1.48	8.88
11	4	2	3	1	6	5
12	3.6	1.2	2.4	4.8	6	7.2
13	3.27	1.09	2.18	4.36	5.45	6.54
14	6.55	3.93	5.24	1.31	2.62	7.86
15	2.1	1.05	3.15	5.25	4.2	6.3
Suma A_j	95.17	46.14	74.79	47.41	73.3	120,08
$Q_{(2)}$	5	1	4	2	3	6

Checking the degree of concordance between the views of experts is made by calculating a consensus coefficient w, the formula (2):

$$w = 12 \frac{\sum_{j=1}^{k} \Delta_j^2}{m^2 (k^3 - k) - \sum_{i=1}^{m} T_i} \quad (2)$$

$$\Delta_j = \left| \sum_{i=1}^{m} a_{ij}\delta_i - \frac{1}{n} \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij}\delta_i \right| \quad (3)$$

$$T_i = \sum_{j=1}^{k} (t_j^3 - t_j) \quad (4)$$

M = number of specialists = 15

tj = number of identical rank of a particular value assigned by the expert i.

Then it is chosen from the table the critical value α of F tab criterion, where α = significance level = 0.05, ν_1 = INT (k-1-2/m), $\nu_2 = (m-1)\,\nu_1$ and the two values are compare. [5]

Note that the completion stage number two and number three is not compulsory stage, and the processing of data can later apply after any step. In the next step, check the degree of consensus of experts with Fisher criterion.

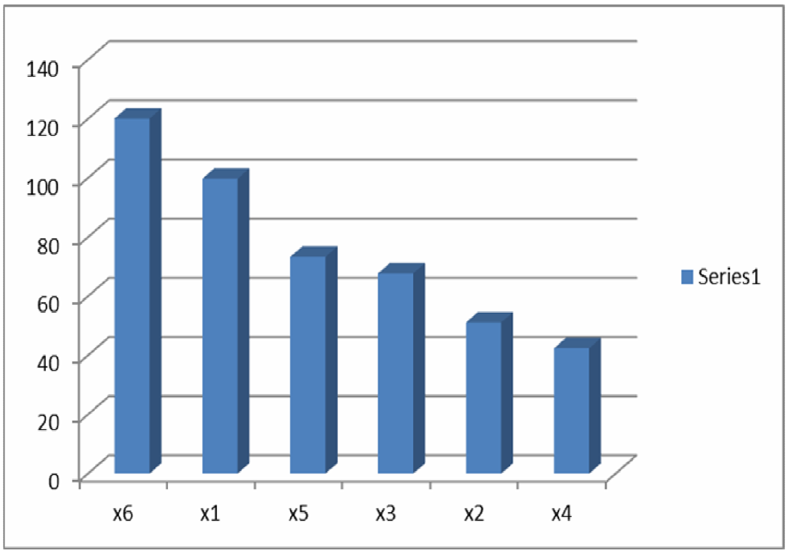

Figure 1 Hierarchy of factors influence

Analyzing this order of influence factors can be grouped into three main categories. It may come off the idea that stress can result from clear misunderstanding of nanotoxicity.

A schematic representation of the sequential testing approach proposed for nanomaterials manufactured by Nurkiewicz help in this case when there is a clear understanding of nanotoxicity.

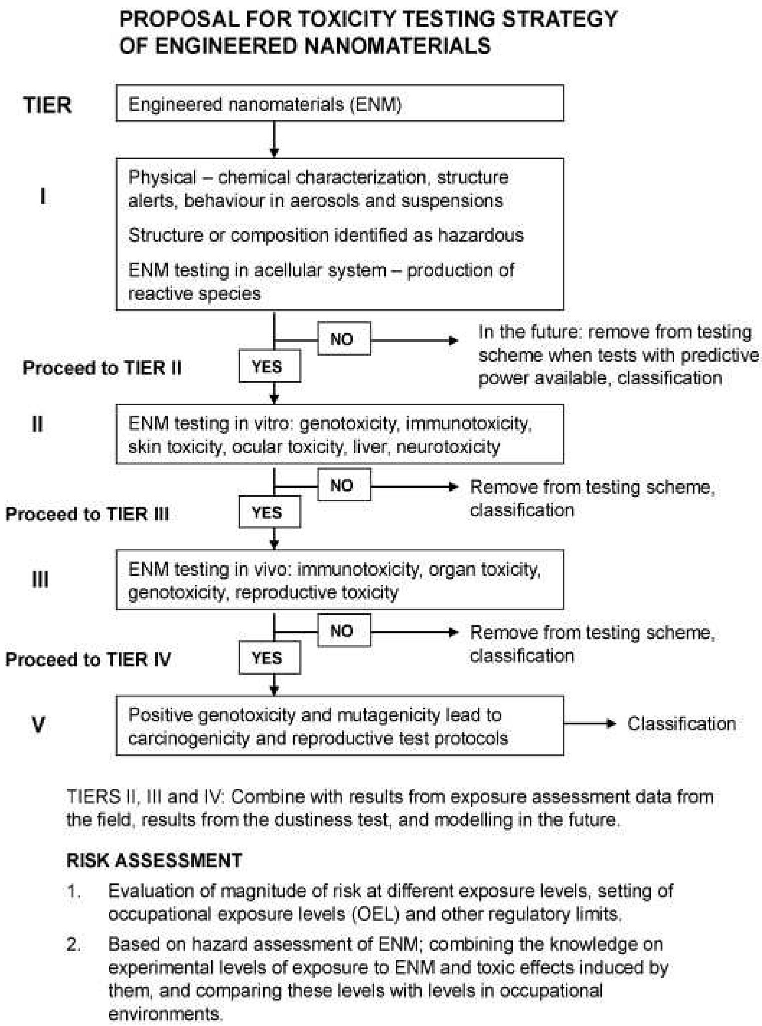

Figure 2 A schematic representation of the proposed tiered testing approach for engineered nanomaterials after Nurkiewicz [9]

Results from rapid testing methods should be made available for the toxicity assessment of ENM to avoid excessive burden to the risk assessment process of ENM. Results from acellular test systems and carefully validated in vitro tests and high-throughput methods using proteomics and genomics as well as systems biology approaches should be made available for the risk assessment.

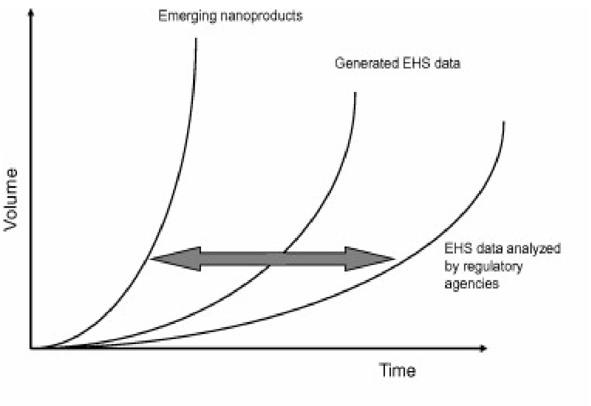

Figure 3. Schematic representation of emergence of nanotechnology products in comparison to generated environmental, occupational health, and safety data as modified according to Linkov and Satterstrom [10]

Usefulness of the proposed method is that it allows independent ranking factors, elimination of the insignificant and focusing on the important, positive effects on energy consumption and materials, so the costs involved by organizing an experiment.

4. CONCLUSIONS

Because of increasing pace of nano- and material sciences and entry of nonmaterial-based materials and products to the marked and subsequently rapidly increasing exposure of workers and consumers legislation based regulatory actions are unavoidable. However, also in the future dynamic interactions between the scientific and the regulatory communities, consumers and the industry are crucial to assure the safety and health of workers and consumers exposed to ENM in their daily work. [11] These approaches are also necessary for allowing the utilization of the technological, scientific and economical benefits of nanotechnologies. The *nanotechnology* can be considered in many cases a conventional or non-conventional technology [12]. In this new century with increasing demand of nanotechnology apart from the potential benefits, scientist and engineers must also anticipate and characterize potential risk associated with new technology and for stress evaluation. Although there are currently no conclusive data or scenarios that indicate that these effects will become a major problem or that they cannot be addressed by a rational scientific approach. At the same time, we can no longer postpone safety evaluations of nanomaterial. Even though several factors are involved in the toxicity of nanomaterial, more efforts and time are needed to study nanoproduct and their properties. Thus all the workers in the field should take all the necessary precautions to protect themselves during the production, handling, and consumption of nanomaterial. Nanomaterials are considered to be hazardous materials, so workers should follow all the safety rules necessary in the field and laboratory where they operated.

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