Directions and possibilities of the safe nanowaste management

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Introduction

Nanotechnology is a field of growing scientific interest due to the properties of engineered nanomaterials (ENMs) which are utilized in a broad spectrum of applications. The International organization for Standardization (ISO) classified nanomaterials into three main groups: nanoparticles (all three dimensions between 1 and 100 nm); nanoplates (one dimension between 1 and 100 nm); and nanofibers (two dimensions between 1 and 100 nm). It was estimated, that in the year 2010 the global production of ENMs varied from 268,000 to 318,000 metric tons and it has since been increasing at a rate of about 25% per year [1–4]. Manufactures ENMs are classified as: carbonaceous nanomaterials (e.g., carbon nanotubes); semiconductors (e.g., quantum dots); metal oxides (e.g., zinc oxide); nanopolymers (e.g., dendrimers) and metals (e.g., silver). They stand out in order from most to least produced ENMs: TiO_2>SiO_2>ZnO>Fe and FeOx>Al_2O_3>CeO_2>CNT>Ag [1, 5–6].

Nanomaterials can be released to the environment at any stage of the life cycle of products (LCA- Life Cycle Assessment), from the manufacture, use, and disposal or recycling processes. In the environment ENMs can undergo a number of potential transformations that depend on the properties both of the nanomaterials and of the receiving medium. The effects of many ENMs on human health and environment are not yet well understood. Not all ENMs possess hazardous properties. Not infrequently, studies performed on the same type of nanomaterials are inconsistent, because some studies show their biocompatibility, while others prove their potentially hazardous nature [7–10]. The hazardous nanomaterials as the new kind of pollutants have been named „nanocontaminants".

The assessment of potential (environmental) risk from nanomaterials in wastes requires information on the hazardousness of nanomaterials which can be emitted from waste and data on their environmental fate and possible exposure levels. Despite the observed trend of ENMs using and the associated risk, generally waste containing nanomaterials are currently disposed of together with another (conventional) waste without any special precautions or treatment. This raises the question as to whether existing waste treatment processes are able to effectively minimise the risk that may be linked to ENMs?

Nanowaste

The term nanowaste refers to waste that contains materials with nanoscale dimensions. Nanowaste management is a new challenge, which focuses attention of many researchers. It emphasizes the need for continuous monitoring of the fate of nanoproducts and suggests recycling as a way to reduce the amount of nanowaste [4, 11]. Also, there is a need to develop research in the scope of nanowaste treatment and to reduce the unintentional release into the environment. But the lack of adequate tools and methods to measure emissions of nanoparticles accurately and significant gaps in data, monitoring, and technology hinder the precise determination of nanoparticle emissions [5]. On the other hand, governments have to take a proactive approach towards developing a waste strategy for nanomaterials, for prevention against long-term unintended consequences.

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Disposal pathways

At present three disposal pathway are distinguished for wastes contained nanomaterials: landfill, thermal treatment (incineration) and material recovery (recycling).

Landfill

The European Landfill Directive (1999/31/EC) defines the requirements on the construction and operation of landfills, including the type and thickness of the soil liners, pH-control and containment conditions of the landfill body, the drainage and treatment of leachate as well as the landfill coverage and capture of landfill gases. If waste containing nanomaterials is landfilled, e.g. for non-recyclable construction waste and shredder waste, there is a potential for leaching of the nanomaterials from waste to the leachate and give rise to concern because nanomaterials may have undesired impacts on the anaerobic and aerobic processes in the landfill (waste decomposition and leachate treatment). On the other hand, landfill conditions would support agglomeration and immobilization of nanomaterials, therefore reduce their emissions. In case of carbon nanotubes, the scientific data present, that any organic acids in the leachate are shown to reduce the agglomeration of CNT and the diffusion of CNT through a HDPE membrane did not take place [12–13].

Thermal treatment

Various materials (products, residues et cetera) with and without nanomaterials are incinerated at high temperature in thermal treatment plant. For incineration, the general agreement is that the nano-inorganics, TiO_2, ZnO, and Ag will end up primarily in the slag and some degree in the filter ash. According to the state of the art of incineration plants the exhaust gas is cleaned using filters and washers. Slags and ashes remain in the incinerator's furnace. Studies of incineration of waste containing nanomaterials indicated that the presence of ENMs in the waste could increase the amount of emitted nanoparticles into environment substantially. There are different viewpoints on, to which extent the agglomeration of the particles may differ due to the presence of ENMs [12–13]. There is a potential leaching of the nanomaterials, when the slag is used in road construction and similar [12]. Furthermore, at any point in the process, nanoparticles may catalyse the formation or destruction of other pollutants and impact the efficiency of emission reduction technologies, particularly dioxins, furans and polycyclic aromatic hydrocarbons (PAH) [13–14].

Material recovery

Nanomaterials reach the processes of material recovery via end-of-life products as well as from other material streams. The recycling processes depend on the product and material type and hence also the conditions are different to which the product matrices containing nanomaterials are exposed. For recycling, effects can be divided into three types: occupational health effects in connection with the recycling processes themselves; environmental impacts related to the treatment of residue from the recycling processes, which will end up either in incineration, landfill or sewage treatment, where the above statements apply; introduction of residual nanomaterials into products containing recycled material, the effect of which is difficult to assess in general [12]. Unfortunately there is very little information on the use of recycled nanomaterials into new products – only the recovery of nanosilver from photo-chemical waste-waters was highlighted [13]. Another specific issue is the recycling of tyres. A very high percentage of worn tyres is recycled, and the granulated material is used as filler on artificial grass on football fields and for rubber tiles and carpeting used on sports arenas and on playgrounds for children. Potentially, the presence of nanomaterials in the tyres could thus lead to leaching of nanomaterials from the recycled products [12].

Furthermore the use of sewage sludge as the pathway of nanowaste disposal is discussed. The application of sewage sludge on agricultural soils is only possible under certain conditions. Due to sometimes high concentrations of hazardous substances, the use of sewage sludge on agricultural soils is currently under discussion. For example, the content of nanosilver and potentially other (similar) nanomaterials in sewage sludge which is used on agricultural are firmly bound in a sludge-soil mixture and can hence accumulate in soils. Nanosilver and iron oxide particles inhibit the activity of microorganisms, partly already in very low concentrations, and can therefore disturb natural processes in soils [13].

Summary

According to research data, governments and industry must act quickly to address the impacts of rapidly rising volumes of nanowaste. Management of nanowaste should be performed with particular care to ensure that nanomaterials that have the potential to pose a threat to human health and the environment are not released. Nanomaterials that are hazardous, toxic or chemically reactive should be neutralized. Where possible, nanowaste should be recycled. The disposal procedures for handling nanowaste must be based on current knowledge and take into account existing legislation. Depending on the type of the material, thermal, chemical, physical or biochemical processing of nanotechnology-containing waste is possible to deactivate them.

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ZMIANY PERSONALNE

Nowy Członek Zarządu BIOMED-LUBLIN

21 września br.Rada Nadzorcza BIOMED-Lublin WSiS SA podjęła decyzję o powołaniu do składu zarządu z dniem 1 października Spółki Pana Adama Siwka. Zmiana ta ma wzmocnić Spółkę nie tylko w realizacji układu z wierzycielami, ale również w poszukiwaniu nowych możliwości rozwoju. Adam Siwek ukończył studia ekonomiczne Akademii Ekonomicznej (dzisiejszym Uniwersytecie Ekonomicznym) we Wrocławiu, a także Studium Podyplomowe w zakresie aspektów ekonomicznych, ekologicznych i technicznych energetyki. Karierę zawodową rozpoczął w firmie doradczej EconTrade Sp. z o.o. jako Szef Biura Analiz i Wiceprezes Zarządu. Współwłaściciel firmy doradczej INERCON Sp. z o.o., gdzie w latach 2002–2009 pełnił funkcję Członka Zarządu. W latach 2009–2011 związany z KGHM Energetyka Sp z o.o. kolejno na stanowisku Wiceprezesa ds. Ekonomiczno-Finansowych, a następnie Prezesa Zarządu. W latach 2012–2013 był Członkiem Zarządu, a następnie Wiceprezesem i Dyrektorem Pionu Inwestycji Strategicznych PGNiG Termika SA. W latach 2014–2015 Prezes Zarządu Towarzystwa Finansowego SILESIA Sp. z o.o., skąd odszedł, by objąć stanowisko Dyrektora ds. Strategii i Rozwoju Torpol Oil&Gas Sp. z o.o., pełnione do sierpnia 2016 r. Członek Rad Nadzorczych WPEC Legnica SA, TFS Sp. z o.o., PLL LOT SA, TORPOL SA. Członek Polskiego Towarzystwa Elektrociepłowni Zawodowych, Word Energy Council, oraz Business Centre Club. Adam Siwek posiada bogate doświadczenie w analizie przedsiębiorstw i przygotowaniu długofalowych planów strategicznych i oraz inwestycyjnych. Nadzorował liczne projekty opracowania planu restrukturyzacji i wdrożenia strategii skierowanej na wzrost wartości firmy. *(kk)*

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