A Consumer's Guide to Nanotechnology

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Introduction:

Nanoparticles refer to particles, either naturally occurring or synthetically engineered, that range in size from 1 to 100 nanometers, and nanotechnology refers to the design, creation, and usage of nanoparticles for a variety of reasons. To help grasp how truly small nanoparticles are, here are some comparisons: a single human hair is around 80,000-100,000 nanometers wide and a single sheet of paper is approximately 100,000 thick (National Nanotechnology Initiative, n.d.). Engineering particles at the nano level is not actually a new concept; it dates back to a talk that Nobel Physicist Richard Feynman gave in 1959 (Feynman, 1960). The usage of nanotechnology, however, has become more common across a variety of different sectors (Malik et al., 2023). Given the increasing popularity of nanotechnology, it is important for consumers to be informed about properties, applications, and potential risks in order to make informed decisions about what they are using. Due to their uniquely small size, nanoparticles have distinct properties that set them apart from other materials. Nanoscale materials may have different colors, abilities to reflect light, magnetic properties, flammability, and electrical conductivities to name a few (National Nanotechnology Initiative, 2024). Those changes in physical and chemical properties may also create potential risks. There are, however, a lot of positive applications for nanomaterials. Nanotechnology has allowed for breakthrough advancements to be made in a variety of fields including medicine, energy, manufacturing, and agriculture.

Focusing specifically on the presence of nanotechnology as it pertains to consumers, metallic nanomaterials are the most commonly utilized in consumer goods. The method of implementation for nanoproducts depends on the function of the product, but some methods include using nanomaterials in the coating of a product, dispersing nanomaterials throughout the product, or binding nanomaterials within a product (Yang & Westerhoff, 2014). Nanosilver, nano titanium dioxide, and carbon nanotubes (CNTs) are the most abundant in day to day consumer

products. Nanosilver has antibacterial properties (Kaiser et al., 2023). Due to that quality, nanosilver can be found in socks and other fabrics, medicine, pesticides, and or disinfectant sprays. Nano titanium dioxide has a wide range of applications and can be found in personal care products including cosmetics, sunscreens, and even toothpaste. It can also be found in food and paints both for color, as a whitening agent, or texture purposes. Lastly, multi walled carbon nanotubes can act as flame retardants and can therefore be found in the textile and electronic industries (Yang & Westerhoff, 2014). Knowing that nanomaterials are in so many day to day products, it is imperative to understand how exposures can occur and what the potential health risks are.

Health Risks:

There are specific ways through which exposure to nanomaterials may occur. Not all nanotechnology products will raise exposure issues, and not all exposures to nanomaterials will lead to negative health outcomes. Nanoparticles which are fixed within a medium cannot move around freely and therefore will not result in human or environmental exposure while held in place, these are typically referred to as “embedded”; however, in some circumstances it may be possible for even well-embedded particles to become free (Abbott & Maynard, 2010). An example of this would be a surface with embedded nanoparticles that is not hardened against friction or weathering. To ensure safety as much as possible, it is important to understand the different potential pathways for exposure. The three primary methods of exposure for unbound nanoparticles include inhalation, dermal exposure, and oral ingestion (Yang & Westerhoff, 2014). Inhalation would entail breathing in the nanoparticles, dermal exposure would allow the nanoparticles to come into direct contact with skin particularly through broken skin or an open

wound, and oral ingestion would entail putting the product containing these nanoparticles directly into the mouth. The method of exposure is tied explicitly to the use of the product, for example toothpaste containing nanomaterials would likely lead to oral ingestion and potentially dermal exposure as well. Another aspect is that the exposure may be in-direct; direct exposure would occur during the use of the product by an individual while in-direct exposure would be interacting with the nanomaterials after they have been released into the air from prior use.. Another form of exposure is the direct exposure risks faced by individuals who work with the nanomanufacturing industry. This could include workplaces which produce cosmetics, paints, and polymer composites that contain large amounts of nanomaterials (Yang & Westerhoff, 2014). Workers are required to have protection but the recommendations pertinent to nanotechnology developed by the National Institute for Occupational Safety and Health have not been adopted as regulation. These recommendations show that much greater care must be taken with nanoparticles to prevent their release and exposure to workers, to prevent combustible dust, and to prevent releases in transfer, packaging, cleaning, and manufacturing.

The risk of developing an adverse health effect is linked to the amount of exposure, meaning those who are exposed more frequently, i.e. people who work directly with nanomanufacturing, are more likely to develop a negative health outcome. Once nanoparticles enter into the body, they can spread by way of the cardiovascular system. Such tiny particles enter the bloodstream through respiration more easily than larger particles, because they are not effectively filtered by the respiratory system. Exposure to nanoparticles has been associated with negative cardiovascular, immunological, neurological, and pulmonary impacts, along with carcinogenic effects due to the fact that nanoparticles, while possibly bringing new concerns, are also expected to have the same toxic properties as their larger forms (Employment and Social

Development Canada, 2018). Since nanoparticles are uniquely tiny, they can readily penetrate skin, mucous, and other physical barriers. In doing so, they can cause harmful negative reactions including inflammatory responses (Kumah et al., 2023). They are also able to penetrate deep in the lungs to the alveolar region where the gas exchange of carbon dioxide and oxygen occurs. Additionally nanoparticles have been linked to causing dermatitis, hypertension, and bronchitis (Employment and Social Development Canada, 2018). These are just some of the potential health risks associated with exposure to nanoparticles. Much more research is needed to understand more about the level of risk and severity of negative health outcomes.

Be Prepared:

As a consumer, the best way to be protected is to stay informed and up to date about nanomaterials, especially as research comes out and regulations continue to change. Research products before purchasing them to identify if nanomaterials are present, and if so how they are being used. Are they bound in a medium? Does the product create the potential for exposure? An example of that could be a spray sunscreen containing nanoparticles; the exposure for that would be inhalation or dermal exposure especially through an open wound. Since there is still so much research that needs to be done pertaining to the health risks of nanomaterials for humans, it is best practice to exercise caution when using products containing nano. Pressure should be put on the United States government and health departments to inform consumers of products containing potentially harmful nanomaterials and what to be worried about in general. They also should lay out definitive guidelines for safe development to protect communities as the usage of nanotechnology continues to increase.

Global Framework:

In the United States, nanotechnology is not regulated under nano-specific legislation. Instead, the Environmental Protection Agency (EPA) regulates nanomaterials under the Toxic Substances Control Act (OCSPP US EPA, 2015). This regulates materials in manufacturing, not the commercial products we see on the shelves. The U.S. Food and Drug Administration (FDA) regulates products that have nanomaterials when they are used in certain ways – as medicines, but not as cosmetics, for example. Unlike the US, the European Union has introduced nano-specific regulations and requirements. The European Union has formed the European Union Observatory for Nanomaterials (EUON) where they list all of the nanomaterials that are in use in the EU market. Additionally, they have made sure that sector-specific nanomaterials legislation is laid out for product sectors like food, biocides, and cosmetics (EUON, n.d.). In general, the US assumes products are safe until they are proven to cause adverse effects while Europe validates the safety of materials before putting them into consumer products. Protection from potential risks associated with nanomaterials starts at the beginning. State and local governments should be informed of all the locations and businesses that manufacture and process nanomaterials which is not currently happening in the US. That will ensure protection for workers and help to prevent nano emissions by air, water, and waste. Knowing the location of nano businesses will also allow governments to make sure that the corresponding waste and wastewater treatment facilities are properly equipped to adequately treat the waste and prevent nanomaterials from making their way into water systems and harming marine life. Given the lack of these protective regulations and databases for consumer products containing nanomaterials in the US, there are some resources listed below to provide more about nano and products containing nanomaterials.

Helpful Resources:

1) OSHA Fact Sheet: Working Safely with Nanomaterials
2) Continuing to Protect the Nanotechnology Workforce: NIOSH Nanotechnology Research Plan for 2018 - 2025
3) The Nano Database (developed by the DTU Environment, the Danish Ecological Council and Danish Consumer Council)
4) Nanotechnology Products Database
5) Municipal Response to Nanomaterials Use

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