



Analytical Methods to Detect Nanomaterials on Biological Systems

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DESCRIPTION

Nanoscience is a field that is constantly evolving and progressing in various fields such as medicine, energy, electronics, biotechnology, and materials. Engineered Nano Materials (ENMs) and Nano Particles (NPs) are simply defined as materials with sizes in at least one dimension between 1 and 100 nm. This definition means that it can be modified and modified to perform its intended functions and tasks due to its various chemical and physical properties. Moreover, due to the wide variety of nanoparticles, they are currently being incorporated into common daily products such as food preservatives, cosmetics, and clothing in several areas of research. This constant and invisible contact with nanoparticles has inspired the field of nano toxicology to study the greater impact of these ENMs on both biological and environmental systems. Due to limitations in analytical instrumentation and analytical test methods that are directly applicable to the determination of ENM in the environment and biological matrices, nano toxicity has been unable to keep up with the continued research and development of nanoparticles and nanoparticle-based materials. It remains undeveloped territory because it struggles.

A distinguishing feature is the size of the nanoparticles, which allows them to be chemically distinguished from larger particles and bulk materials. An additional unique bio-cell interaction occurs in the form of surface charges on ENMs, with anionic and neutral ENMs generally exhibiting lower toxicity than cationic materials. The surface charge of ENMs can also have an additional effect on the overall shape of the particles, and the shape of ENMs can also alter the cell membrane, thus strongly influencing the cellular uptake mechanism. ENM surface coatings may alter toxicity and contribute to cell death by providing additional electrostatic forces, molecular adhesion and atomic layer deposition. Moreover, the elemental composition of ENM contributes to its overall toxicity to both biological and environmental systems. Such elements range from transition metals (gold, silver, copper, iron, etc.) to non-metals (silica, carbon). They can vary greatly in size, morphology, coatings, and physical and chemical properties as previously mentioned.

As mentioned above, there is no single method to accurately detect ENM and NP toxicity because there are many factors that influence ENM and NP toxicity. Rather, there are several methods commonly used together to characterize ENMs and NPs and their overall toxicity. Dynamic Light Scattering (DLS) is most commonly used to determine hydrodynamic particle size, and zeta potential determines the surface charge of particles. At the same time, methods such as Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) allow visual detection of ENMs and NPs, allowing us to measure their size distribution. These methods provide insight into ENM and NP properties, but not toxicity analysis. Researchers use *in-vitro* and *in-vivo* tests.

To first examine *in-vitro* toxicity, the standard measurement technique for measuring ENM and NP toxicity in *in-vitro* studies is the MTT assay (3-[4, 5-dimethylthiazol-2-yl]-2 Cellular mitochondrial function by detection of mitochondrial dehydrogenase by enzymatic reduction. Another standard measurement technique for judging toxicity is the examination of her ROS formation in cells. This indicates oxidative stress and impaired cellular function. Fluorescent ROS tracers are commonly used to measure intracellular ROS. In the presence of ROS, this indicator chemically changes and emits different fluorescence signals. This signal can be observed with fluorescence spectroscopy or confocal microscopy. Additionally, there is concern that particles may accumulate unintentionally in organs and induce toxicity in *in-vivo* studies. Potentially dangerous NPs are directly or indirectly introduced into organisms by measuring toxicological endpoints. Some nanoparticles such as gold-based and other metal-based NPs exhibit toxic effects and accumulation in organs. However, the toxicity pathway is not fully understood. The most commonly examined organs affected by NP accumulation are liver, heart, kidney, spleen, lung, intestine, and stomach. The liver and other organs with high blood flow are the most common sites of unintended accumulation. Which organs are more affected depends on the elemental composition and size of the NPs. For example, carbon-based NPs show the most unintended accumulation in the liver. However, small carbon-based particles

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Received: 27-Jan-2023, Manuscript No. MCA-23-20596; **Editor assigned:** 30-Jan-2023, PreQC No. MCA-23-20596 (PQ); **Reviewed:** 13-Feb-2023, QC No. MCA-23-20596; **Revised:** 20-Feb-2023, Manuscript No. MCA-23-20596 (R); **Published:** 28-Feb-2023, DOI: 10.35248/2329-6798.23.11.402

Citation: Pinnet M (2023) Analytical Methods to Detect Nanomaterials on Biological Systems. Modern Chem Appl. 11:402.

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less than 20 nm in size, such as quantum dots, were shown to have increased accumulation in the brain parenchyma.

Quantum dots can cross the BBB pathway and the trigeminal nerve or olfactory epithelium, which can pose additional problems in *in-vivo* toxicity studies. Despite the accumulation of carbon-based particles in organs, carbon-based NPs typically show little or no significant increase in toxicity when examined *in-vivo* due to their chemical composition.

CONCLUSION

Silica NPs accumulate most strongly in liver, lung, and spleen, with some accumulation in kidney. A histological study of silica-based NPs showed that NPs had no adverse effects on organs if removed within months. For NPs composed of less toxic chemicals such as carbon and silica, size has a greater impact on toxicity than chemical composition. In general, smaller particles are more toxic. This allows for better interaction with cellular components such as proteins, fatty acids and nucleic acids. However,

large silica NPs have also been shown to be more toxic than small silica NPs. Polymer- and metal-based nanoparticles with low clearance rates generally exhibited the greatest toxicity and organ accumulation, sometimes involving major metabolic disturbances. However, some limitations remain in the *in-vivo* analysis of organ accumulation and long-term toxicity of NPs.

In some studies, the lack of macrophage uptake and blood circulation suggests the need for better assays, *in-vivo* animal studies do not always translate into human studies, as detection of *in-vivo* toxicity and assignment to NPs becomes more complex. Furthermore, most *in-vivo* studies examine toxicity through analyzes over weeks or months.

Years of analysis are rarely explored in research, mainly due to time constraints, but they are meaningful and essential. Nonetheless, these are all important parameters when studying *in-vivo* nano toxicity, especially when examining the complexities of human health, and improved test parameters and animal models for more accurate toxicity assessment.