

# A Perspective: Nanoparticle Plus Analytical Chemistry = “Nanolytical Chemistry”?

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Nanoparticles are important for drug delivery, cancer therapeutics, bioanalytical labeling, food additives, and cosmetics. The environmental, health, and physiological effects of the manufacture and applications of nanoparticles have not been intensively investigated. When nanoparticles are delivered into the human body as carriers of therapeutics, their side-effects on health and physiology are currently not clear. When nanoparticles are discarded they can be considered as “nanowastes” that cause “nanopollution”. Nanoparticles can float in the air and can disperse in water. Nanoparticles are more reactive because of their relative surface area and surface energy. Most artificial nanoparticles do not exist in nature, so living organisms may not have evolved to deal with them.

Despite some progress in understanding the environmental, health, and safety risks of nanoparticles, the types and amounts of nano materials in consumer products – and their possible applications and risks – remain uncertain, according to a report from the National Research Council (C&EN January 30, 2012). It is necessary to know the amount (number) of the nanoparticles and then to investigate their effect quantitatively. Here raised a question: how to determine the total mass or number of nanoparticle in a solution and then how to quantitatively evaluate the health and physiological effects.

Challenge and opportunities of nanoparticle content determination come from the fact that nanoparticle solutions are not “real solutions”. Each individual particle can be considered as a solid phase in a liquid suspension. A suspension is, theoretically, thermodynamically not stable due to its relatively large interface energy. Traditional methods that have been used to analyze the “concentration” of a chemical in a solution may not be suitable for the analysis of the “population” of nanoparticles in a suspension, especially methods that are based on the colligative properties of solutions. The total mass of nanoparticles in a colloidal dispersion is very small. Highly sensitive methods are needed to measure either the total mass or the number of nanoparticles in suspensions. Quantitative analytical chemistry analyzes chemicals at the molecular level. On the other hand, there are other well-developed engineering methods in characterization of fine particles that are 0.1  $\mu\text{m}$  (100 nm) or larger. When nanoparticles are used as carriers of drug delivery or labels of bioanalysis, the biomolecular conjugated nanoparticles will be transported into human, animal, or plant tissues, soil, or natural water systems. These natural systems contain many different types of particles, biomacromolecules, and minerals. Therefore, a particle counting method needs to deal with the existence of interferences. Nanoparticles usually have an average diameter between 1 nm and 100 nm, which is covered by neither “chemical analysis”, nor fine particles characterization.

There are mainly two ways to approach quantitative nanoparticle analysis. One is to directly count the numbers of nanoparticles by mass spectrometry, spectrophotometry, or light scattering methods. The other way is a combination of size characterization method such as transmission electron microscopy and chemical analysis methods such as amperometry and inductively coupled plasma mass spectrometry. Both of these approaches are based on current materials analysis

methods that can be used for the characterization of nanoparticles over 1-100 nm. Direct counting methods are straightforward, but have limitations in the range of nanoparticle diameters. Neither mass spectrometry nor the condensation nuclei counter technique can cover the whole range from 1 nm to 100 nm. Chemical elemental analysis provides the lump-sum of an element that consists of the entire nanoparticle as a whole. However, ions and complex compounds in the matrix can interfere with the results.

Although analytical chemistry has been established and developed during the past century, tremendous work and new methods are needed in the area of nanoparticle analysis. On the one hand, new protocols of sampling and calibration will be developed specifically for nanoparticles based on existing instrumental methods or wet chemistry. The protocols and the methods may vary depend on the average size of nanoparticles, size distribution, and the methods that will be used. On the other hand, new techniques that can directly characterize the number of nanoparticles may be discovered. Either way, development of new methods for quantitatively determining nanoparticle content may lead into new areas or development of new physical or analytical concepts.

Finally, I would like to emphasize the importance of “open access” to this emerging new discipline of science. Nowadays, the frontlines of scientific research are the borderlines. Current dynamic research areas are all interdisciplinary. For example, the aforementioned “nanolytical chemistry” can be an overlap of nanomaterials, biochemistry, biomedical science, physiology, environmental science, etc. In order to prompt new concepts and developments in this new area, the efforts of scientists and engineers from all disciplines are needed. The open access journals that focus on inter-disciplinary areas provide a platform for readers and researchers from all areas to access the latest research results and to share ideas. In addition, I believe the peer-reviewed scientific journals should not be only available for a small group of “doctors”. “Open access” makes new knowledge available for reading and discussion by any interested person, without an institutional subscription to a series of journals. Therefore, “open access” provides not only a scientific research forum, but also a scientific education platform that impacts our society at large.

“Open access” journals are a new type of scientific publication that has appeared in the last few years since the Internet became a major media of information broadcasting. The new media - “open access” journals - may flourish and promote the development of new scientific research areas.

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