The Nanoparticle Problem

Nanoparticles have received their share of attention the past several years in the occupational health world. Why now? Nanoparticles have been around as long as our existence. This increased attention is the result of newer technology developed over the last couple of decades to create "engineered nanoparticles". These engineered nanoparticles are being produced and used in numerous ways to improve commercial goods. Some examples are skin creams, paint additives, and fabric softeners.

Thus workers involved in these manufacturing activities are being exposed to levels of nanoparticles not previously seen. Employers have started to look to regulatory agencies for sampling methods and exposure standards, yet nothing has been in place until NIOSH the Current Intelligence Bulletin #63[1] in 2011 to address nano-sized particles of Titanium Dioxide. Work continues in determining the health effects of nano sized particles. NIOSH in particular has done substantial research and has setup a webpage specific to nanoparticles at http://www.cdc.gov/niosh/topics/nanotech

Now that nanoparticles are a concern, how do we sample for them? Lets look at some currently available methods and some of the obstacles associated with them:

Method	**Problem**
Respirable Sampler onto MCE filter	Collection of both larger particles and nano-size particles without separating out only the nano-sized portion. Typically exhibits 50% cut-point around 4µm and collects at 100% less than 1µm. This results in a mass measurement that can then be dominated by larger particles. A work-around may be performed to determine percentage of nano-size vs larger particles but this requires additional samples and costly electron microscopy.
Other size selective samplers (inhalable, thoratic, etc)	Not designed to selectively collect only nano sized particles. Exhibit same problem as respirable samplers.
Direct reading instruments	Expensive Not designed to measure personal exposure Cost, size, and wear-ability not ideal for personal use. Not chemical specific. May only provide a quantity of particles.

Enter The Zefon NRD Sampler

The Zefon Personal Nanoparticle Respiratory Deposition (NRD) sampler is designed to size-selectively collect nanoparticles with an efficiency that matches their deposition in the respiratory tract system.

Features:

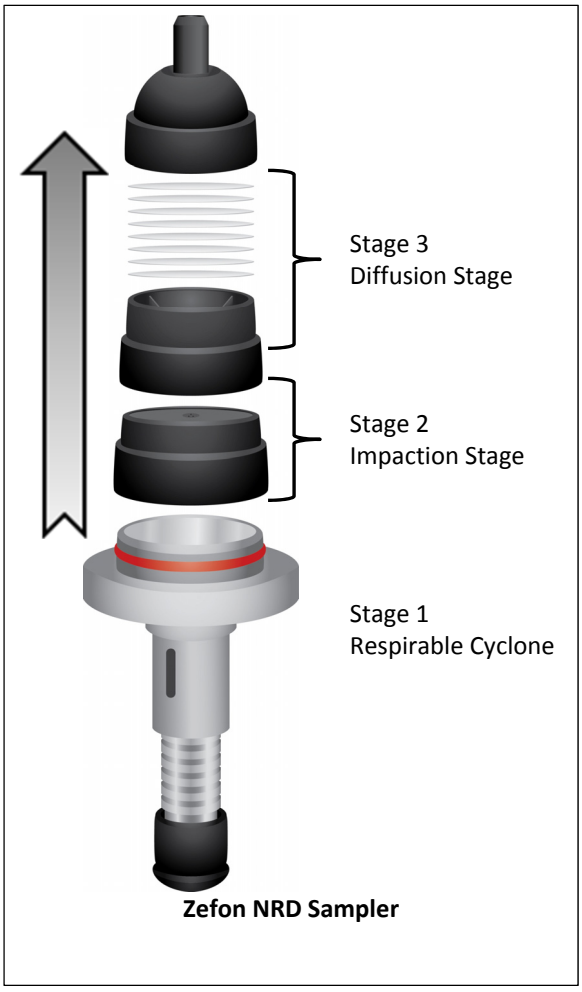
- Engineered to collect particles likely to be deposited in the respiratory tract.
- Filters out larger unwanted particles.
- Lightweight; Designed to be worn for personal exposure sampling.
- Use with standard 25mm aluminum cyclones
- Compatible with personal sampling pumps capable of a 2.5LPM flow rate at 15" H_2O backpressure
- Analyze with lower cost chemical analysis techniques vs electron microscopy

How it works:

Stage 1 – A respirable aluminum cyclone (Zefon #ZA0075) at a flow rate of 2.5 LPM is used to remove particles larger than 4µm in size.

Stage 2 – Air passes through an impaction stage where particles larger than 300nm are removed using an impaction plate.

Stage 3 – Air passes through a diffusion stage consisting of a series of Nylon filters, collecting particles <300nm with an efficiency designed to match the efficiency at which particles deposit in the respiratory tract.



Zefon NRD Sampler

FAQ

Q1. Why should I be concerned about nanoparticles?

A1. Nanoparticles have been around for many years. Over the past couple of decades, technology has been created to manufacture materials that are nano-sized. These manufactured materials are sometimes called “engineered nanoparticles” or “engineered nanomaterials”. This development of engineered nanomaterials has resulted in their use in a growing number of commercial products. Thus workers are now subjected to exposure to these materials at levels not previously seen. This exposure is a health concern.

Q2. What size are nanoparticles?

A2. According to ISO 27687:2008, a nanoparticle is defined as a nano-object having all 3 external dimensions at nanoscale (approx. 1-100nm).

Q3. What is the difference between a nanoparticle and an ultrafine particle?

A3. Both nanoparticles and ultrafine particles can be in the same 1-100nm size range. This creates confusion among many people. One common method to distinguish the two as follows:

- Ultrafine Particle is sometimes used to describe “incidental nanoparticle”. Those are particles in the same <100nm range, but are not purposely manufactured. They are often a byproduct of some other process, such as combustion.
- Nanoparticle is sometimes intended to refer to “engineered nanoparticles”. Engineered nanoparticles are particles that are manufactured for use in a commercial product or for use in a production process.

Ultimately there are some different uses of the two terms in industry to be aware of. While it is not uncommon to see the term nanoparticle used to describe engineered nanoparticles and the term incidental nanoparticle may be referring to ultrafine particles this sometimes differs. Some published papers will explain how terms and definitions are used in their publications. It is best to look and see if the publication you are reading provides their interpretation.

Q4. What purpose do engineered nanoparticles have?
A4. Engineered nanoparticles have been found to be useful in improving some commercial products. For example, it is a common additive in sunscreen, cosmetics, and paint.

Q5. If nanoparticles are normally defined as having a size less than 100nm, why is the NRD sampler designed to collect 300nm or less?
A5. The NRD sampler is designed to determine the respiratory exposure a worker is subjected to. The impactor stage exhibits a d50 cut-point size of 300nm. This effectively removes the larger particles and leaves the <300nm particles to collect during the diffusion stage. Once in the diffusion stage, particles in the <300nm range are collected, however this efficiency is greatest at the <100nm level. Particles collected in the 100-300nm range are not expected to be significant enough to interfere with the analysis.

The key to remember is that the NRD is designed to collect with the same efficiency as human lungs. Not all particles aspirated will deposit in the lungs. Consequently the NRD sampler is not designed to collect particles with 100% efficiency. This is a different concept than current commercially available inhalable and respirable samplers that collect with 100% efficiency [2].

Q6. How do you know what efficiency the human lung deposits particles?
A6. This has been studied researched. An efficiency curve has been developed by the International Commission on Radiological Protection (ICRP)[3]. The efficiency that the NRD collects particles matches this curve.

Q7. Why 3 stages of particle removal?
A7. It is important to remove the larger particles because they may block or mask the presence of the particles of interest. Multiple stages are used so that the method of particle removal will function correctly.

- The first stage with the respirable cyclone uses an existing commercially available cyclone with a known particle cut-off of 4µm when operated at a flow rate of 2.5 LPM. Removal of particles in this stage is important as it allows the impaction stage to function correctly without larger particles overloading the impaction zone or possibly blocking the impaction nozzle.
- The second stage uses impaction to further reduce the particles sizes to 300nm or less. This allows collection in the diffusion stage to effectively measure only the particles of interest.

- The third stage is designed to collect the remaining particles 300nm or less at an efficiency that matches the efficiency human lungs deposit particles.

Q8. Have exposure limits to nanoparticles been defined?
A8. As of October 2013, NIOSH in the US has published an Intelligence Bulletin #63 for Titanium Dioxide exposure using a method of collecting particles on MCE filter media. Zefon is not aware of guidelines being published for other nano-sized particles. NIOSH has communicated publically that it is evaluating exposure methods and permissible levels for nano materials in general. Exposure limit determination has been problematic as published information related to the potential health effects of nanopartciles is not widely available. This in connection with not having commercially available equipment to sample and determine a persons exposure.

Q9. What is the relationship between the Zefon NRD sampler and the one presented by Peters and Cena in the paper "A Personal Nanoparticle Respiratory Deposition (NRD) Sampler"?
A9. The Zefon NRD sampler is the same sampler presented in this paper. Zefon has licensed the technology for this product and developed it into a disposable commercially available product.

Q10. Why not just use an MCE filter in the diffusion stage and collect everything?
A10. It certainly would be possible to do. However the goal of the NRD sampler is to not collect 100% along with a cost effective analysis, namely avoiding the use of costly electron microscopy or multiple samples to determine a percentage of fine vs ultrafine particles. Look at it this way - If the goal of sampling is to determine what is harmful to the worker in the first place, why not try to collect the same amount of particles you would expect the worker to actually have deposited in their lungs?

The NRD sampler provides that opportunity. It is a new method in thinking about collection. It is designed to collect with an efficiency that matches the efficiency at which particles are deposited in the respiratory tract. This is fundamentally different than existing samplers on the market. Human lungs do not deposit 100% of the particles that are aspirated. A efficiency curve to display the efficiency at which lungs deposit particle was developed by the International Commission of Radiological Protection (ICRP). The Zefon NRD sampler is designed to collect particles at this same efficiency.

Q11. Can the NRD Sampler be used to sample for Titanium Dioxide according to the Niosh Intelligence Bulleting #63?

A11.No, use of the NRD sampler does not follow the methods explained in NIOSH intelligence bulletin #63. NIOSH was faced with the task of developing the method based on what was commercially available in the industry at that time. Today there are better options. NIOSH does continuously look for better methods and making the NRD commercially available will make it a choice for consideration in the future.

It is important to note that the original draft of Intelligence Bulleting #63 was the inspiration for developing the NRD sampler. The process of taking multiple samples using electron microscopy, and following the decision flow chart is not an easy and simple process. It is also very costly to perform.

Q12. Are nanoparticles and nanotubes the same thing?

A12. No. Most of the talk about nanotubes relates to "Carbon Nanotubes" which are structures more tubular in nature.

Q13. Does the NRD sampler collect nanotubes?

A13. The Zefon NRD sampler is designed specifically to collect nanoparticles and has not been tested or evaluated for the collection of carbon nanotubes.

References

1. NIOSH Current Intelligence Bulletin #63
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Additional Information Sources

1. Niosh Nanotechnology Information
   http://www.cdc.gov/niosh/topics/nanotech
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3. Nanoparticles: An occupational hygiene review
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4. Approaches to Safe Nanotechnology: Managing the Health and Safety Concerns Associated with Engineered Nanomaterials
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