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Paper/Poster-Abstract Form

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Title: A miniaturized DC sensor for personal exposure monitoring

Abstract: (min. 300 – max. 500 words)

The abstracts for papers and posters must contain unpublished information on your research subject: background, investigation methods, results and conclusions. Graphs and references are very welcome. Acronyms should be avoided. Abstracts with < 300 words can not be considered. General information on products which are already commercially available can not be accepted as presentations for the conference but are very welcome at the exhibition of particle filter systems and nanoparticle measurement instruments.

Thanks to epidemiological evidence, it is well-known by now that nanoparticles cause health problems. However, epidemiological studies take a long time to complete, and a more direct link between nanoparticle exposure and health effects seems desirable.

We have constructed a miniature unipolar diffusion charging sensor, which fits into a shirt pocket. At 300 cm^3, it is probably currently the world's smallest nanoparticle detector. Diffusion chargers measure the amount of charge that accumulates on nanoparticles in a unipolar diffusion charger, and by a lucky coincidence, this is nearly proportional to the surface area of the nanoparticles deposited in the alveoli of the human lung [1] – a quantity which is widely believed by toxicologists to be the most important metric for nanoparticle health effects [2,3].

In the entire instrument design, miniaturization was our top priority. Nevertheless, we took special care to also make the instrument simple to use, robust and affordable. For example, we are using a novel filterless detection method that automatically corrects for the omnipresent zero offset in electrometer measurements while allowing for longer service intervals and needs less warm-up time than previous instruments.

An affordable and miniature personal nanoparticle sampler has a lot of applications, the most obvious being the already mentioned personal exposure

monitoring. This is not only useful for studying nanoparticle health effects, but also interesting for occupational health and safety, where there is a growing concern about engineered nanoparticles. Although the regulatory focus lies on the novel engineered nanoparticles, it should not be forgotten that nanoparticle exposure also happens in traditional workplaces, and probably at much larger scales than with engineered nanoparticles (for example, Diesel exhaust, welding fumes and environmental tobacco smoke to name just a few). A real-time nanoparticle dosimeter can alert its carrier if high nanoparticle concentrations are detected, and thus contribute to a safe working environment. Finally, cheap and simple sensors lend themselves to the implementation of large-scale sensor networks, which allow urban air quality monitoring on an unprecedented spatial and temporal resolution.

[1] W.E. Wilson et al. (2007) J.Air & Waste Manage. Assoc. 57:211-220
[2] R.J. Aitken et al., Occupational Medicine, 2006; 56:300-306
[3] G. Oberdörster et al. (2005) Environ Health Perspect 113:823-839

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Nanoparticle measurement in a shirt pocket

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Motivation

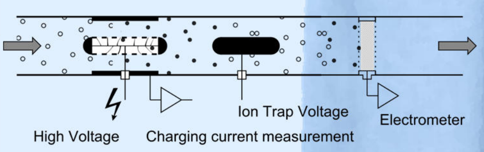
Nanoparticles are easily inhaled and have been shown to be detrimental to human health. Our knowledge on nanoparticle health effects is based on epidemiological studies with huge numbers of participants; unfortunately, the true exposure of each participant can only be guessed at by proxies, such as home and workplace address. For a better quantification of exposure, small, cheap and reliable nanoparticle detectors are necessary, which can serve as nanoparticle dosimeters.

The only type of instrument that currently fits this description is the photometer – however, photometers typically cannot detect particles smaller than 300 nm. Therefore, new developments are needed for nanoparticles.

Principle

To construct small, cheap and reliable nanoparticle detectors, it is obviously advantageous to use a simple principle of operation.

The simplest way of measuring nanoparticles is via electrical charging followed by the detection of the charges carried by the particles by an electrometer – typically, the particles are captured in a filter for this. Instruments based on this well-known principle are known as diffusion chargers (or DC), and are available commercially from some companies. We have also based our dosimeter on this principle, but besides miniaturizing all components, we have also added a few small twists to it.



Innovation

Our dosimeter measures a DC signal, but does so in an innovative way which needs no particle filter, and thus no filter exchanges. This leads to longer maintenance intervals. Besides, our technology automatically corrects for the omnipresent zero offset in electrometer measurements.

Metric

"Current evidence suggests that the most appropriate metric for exposure by inhalation for nanoparticles is surface area. This appears to fit best with current toxicological evidence relating to mechanisms of harm. ... Ideally a personal sampler should be available which could assess this metric. However, none currently exists." [1]

In a DC, particles acquire a size-dependent charge, which is nearly linear in particle size. By a lucky coincidence, this also happens to be very well correlated to the lung-deposited surface area of particles in the size range of about 10-400 nm [2]. Toxicologists have shown that adverse health effects scale better with particle surface area than with particle mass or particle number [3,4].

Key features

Our nanoparticle dosimeter is small (it fits in a shirt pocket), light, and needs little maintenance. It needs no consumables, and has a wide range of particle concentrations and particle sizes that can be detected. With built-in alarm capability, it can alert its carrier when high nanoparticle concentration levels are detected. The battery lasts for about 8 hours.

Conclusions

We have built the world's smallest nanoparticle detector, which measures a highly health-relevant quantity, the lung-deposited surface area. In our opinion, this instrument is useful for several applications, e.g. health studies, workplace exposure control, and ambient measurements.

[1] R.J. Aitken et al., *Occupational Medicine*, 2006; **56**:300-306
[2] W.E. Wilson et al. (2007) *J.Air & Waste Manage. Assoc.* **57**:211-220
[3] G. Oberdörster et al. (2005) *Environ Health Perspect* **113**:823-839
[4] K.M.Waters et al. (2009) *Tox Sci* **107(2)**:553-569