Monitoring Solution for Airborne Carbon Nanotube and Carbon Black Exposure based on Raman Spectroscopy

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Background

Whereas carbon nanotubes (CNTs) are known as engineered nanomaterials that form under specific conditions in a flame environment, there is sufficient evidence that diesel combustion process can also generate CNTs.

In addition to the carcinogenic properties of diesel soot, the potential presence of CNTs in diesel emissions represents an increased risk of adverse health effects due to the high aspect ratio and biopersistence of CNTs. *In vivo* studies indicate that inhaled CNTs can travel to the lungs, enter circulation and cause inflammation, formation of granulomas and pulmonary fibrosis.

Health & Safety Regulation

The National Institute of Occupational Health and Safety (NIOSH) in USA recommends an exposure limit of 1 µg/m^3 of CNTs as a respirable mass, in addition to a permissible exposure limit of 3500 µg/m^3 for carbon black (CB) as an 8-hour time-weighted average concentration. Detecting such small amount of CNTs in the environment, as well as distinguishing it from other combustion particles is extremely challenging with the current sensing solutions.

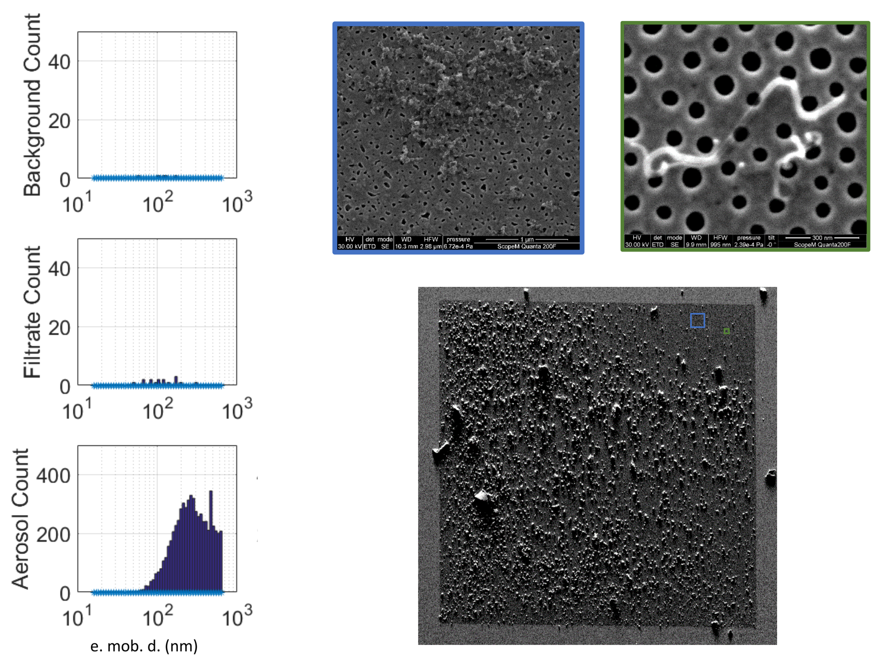
Here, we present a monitoring solution for CNT and CB exposure based on a wearable air sampler and a benchtop reader that utilizes Raman spectroscopy.

Device

A compact air sampler is worn during the workday that captures airborne particles from the user's personal breathing zone. The membrane surface is analysed in the off-hours by an autonomous reader.

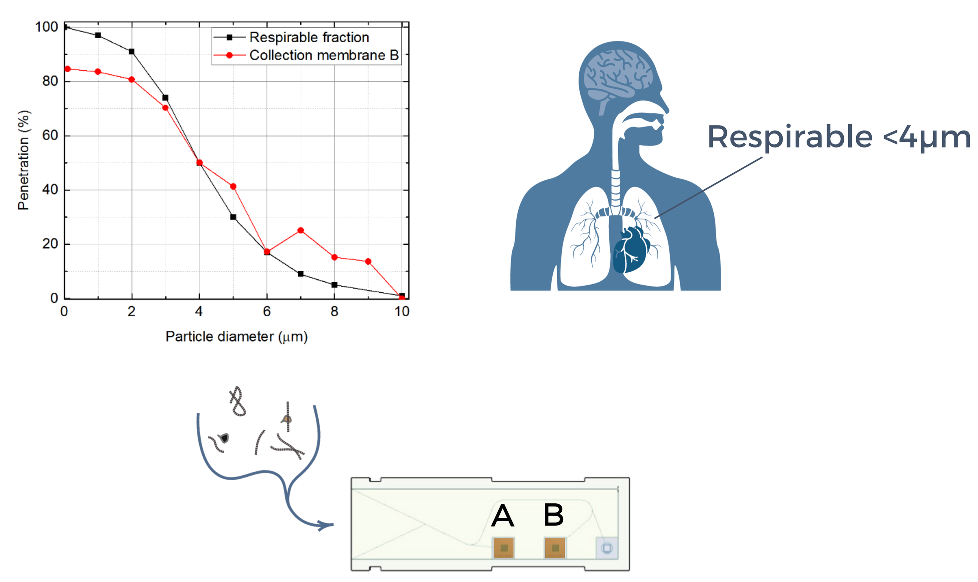
Filtration

Airborne particles are captured by a nanoporous custom-functionalized membrane.



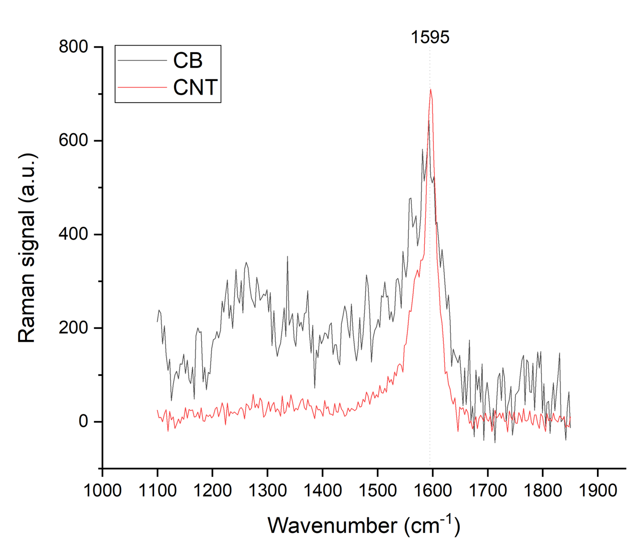
Sorting

The particles are size-sorted using an inertia-based air-microfluidic channel during sampling. Different size fractions are collected on separate membranes.



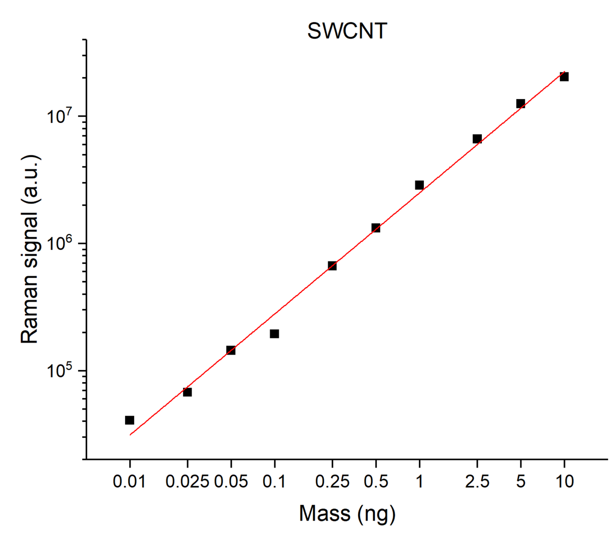
Detection

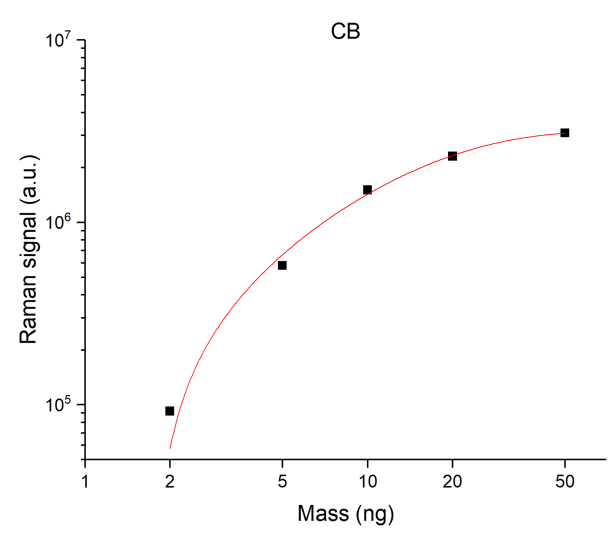
A Raman spectrometer inside the reader rasters the membrane surface. A principle component analysis algorithm identifies the observed materials based on features of the collected spectra.



Quantification

The Raman signal is quantified by comparing the collected signal to a library in the reader. Exposure is calculated by dividing the detected mass by the volume of air sampled.





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