

# An Investigation of Carbon Nanotube Exposure Assessment Methods

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## Background

The National Institute for Occupational Safety & Health (NIOSH) has proposed a recommended exposure limit (REL) for carbon nanotubes (CNT) at  $7 \mu\text{g}/\text{m}^3$ . This REL was set equal to the upper limit of quantitation (LOQ) of Method 5040 reported by NIOSH in the 2010 draft Current Intelligence Bulletin. As a consequence, when CNT exposures are below  $7 \mu\text{g}/\text{m}^3$  there may be no indication as to actual exposure levels.

NIOSH Method 5040 analyzes for elemental carbon (EC) but additionally provides organic carbon (OC) and total carbon (TC) concentrations.

A potential surrogate for Method 5040 is the aethalometer, a hand-held device used to optically measure black carbon concentration, which could be used when conducting CNT exposure assessments to determine CNT levels below the REL.

## Objectives

1. Correlate CNT concentrations measured by Method 5040 to particle count concentrations
2. Correlate CNT concentrations measured by Method 5040 to black carbon concentrations measured with an aethalometer
3. Compare EC concentrations measured by Method 5040 among various CNT types and purities

## Methods

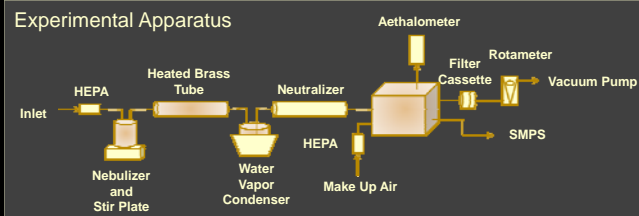
### CNT types & purities:

- 90%, 95% multi-wall CNTs (MWCNT)
- 90%, 99% single-wall CNTs (SWCNT)

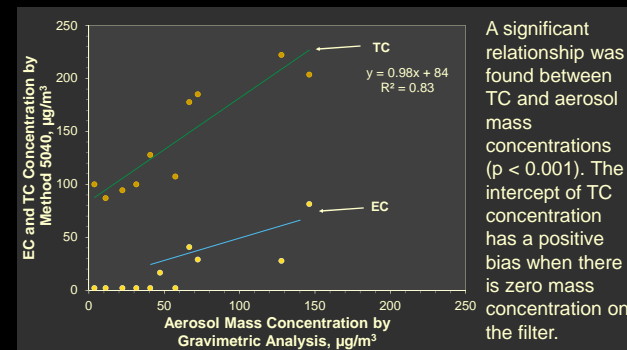
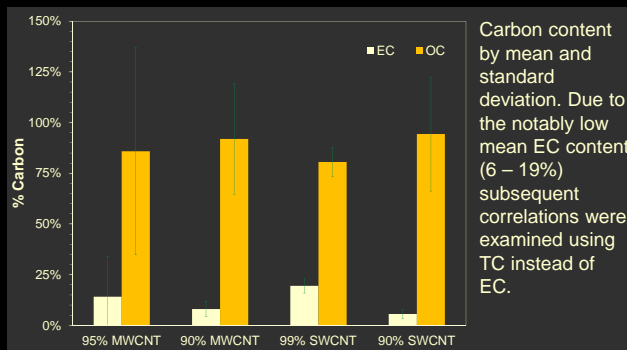
### Measurements:

- Number & mass concentrations  
TSI SMPS: 3080 electrostatic classifier, 3081 DMA 3785 CPC, TSI
- Black carbon mass concentrations  
AethLabs model AE51 Aethalometer @ 880 nm
- Carbon analysis  
25 mm quartz fiber filters in 3-piece cassettes  
NIOSH Method 5040 as EC

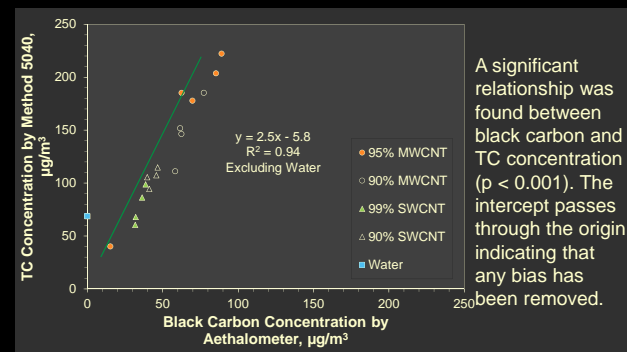
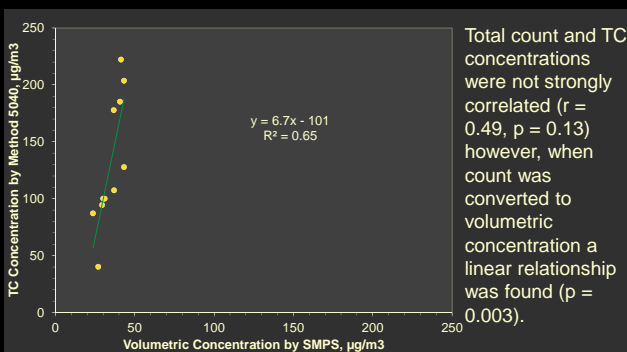
24 filter-based samples were analyzed for EC and OC by Method 5040.



## Results



Aerosol mass concentration was plotted against black carbon concentration measured by the aethalometer (not shown) where the linear relationship indicated that black carbon concentration increased with increasing aerosol mass concentration on the filter ( $R^2 = 0.89$ ;  $p < 0.001$ ). The intercept of black carbon concentration also had a positive bias at  $26 \mu\text{g}/\text{m}^3$  of black carbon.



A two-way analysis of variance indicated that the effect of CNT purity had a significant ( $p = 0.009$ ) effect on EC concentration while CNT type had no effect ( $p = 0.11$ ).

## Conclusions

With strategic sampling, the Method 5040 LOQ can be reduced below the NIOSH proposed REL of  $7 \mu\text{g}/\text{m}^3$  by

1. Using 25 mm filters
2. Increasing the volume of air sampled through the filter

When CNT concentrations are below the Method 5040 LOQ the aethalometer has potential to aid exposure assessment interpretations, however additional research is needed.

Highly pure CNT samples, which have higher EC content, may pose additional health hazards compared to CNTs with lower purities.

## Acknowledgements

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