Research Thrust 4 Social & EHS Implications

Center for High-rate Nanomanufacturing

Northeastern University, University of Massachusetts Lowell, University of New Hampshire

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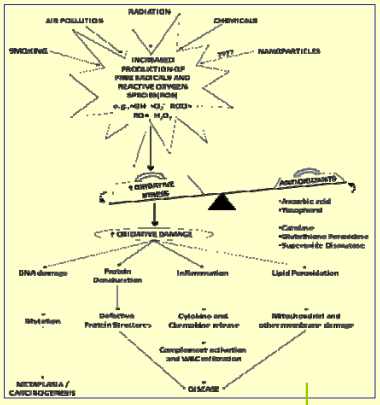
TOXICITY SCREENING

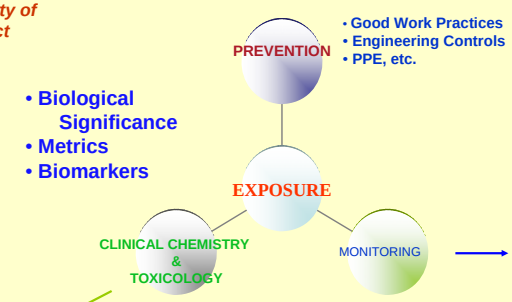
PIs: D. Bello (Work Environment), E. Rogers (Clinical Laboratory Sciences) Graduate RA: S. Hsieh

"Oxidant activity has been shown to be a property of particulate matter and its components that reflect crucial biological mechanisms."

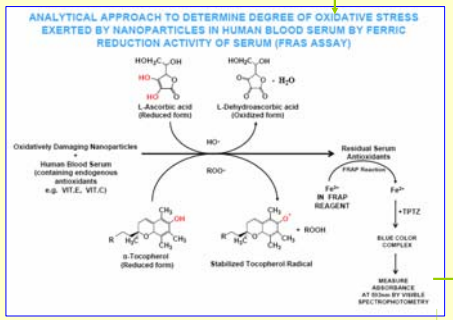
Borm et al. *Occup Environ Med* 2007; 64:73-74.



- **Biological Significance**
- **Metrics**
- **Biomarkers**



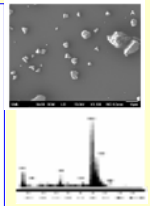
- **Characterization**
- **Integrated Approaches**



- TSI FMPS 3091
- Naneum WRASS 05 integrated sampling (1 nm-35 um in 12 stages) for microscopy characterization (EM) and chemical analysis
- Thermal precipitator for EM & EDS

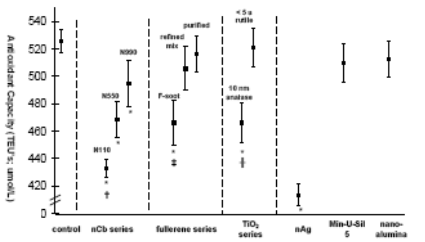
The particle size of nanoparticles and the effect on the antioxidant capacity of human blood serum.

Nanomaterial (NM)	Primary particle size of NMs (nm)	Typical particle size range in serum by FE-SEM (nm)	% Change
Nano silver	58	1-10	-21.2*
Carbon black N110	15	0.5-5	-17.1*
Carbon black N550	44	1-10	-11.2*
Carbon black N990	> 200	1-10	-5.9*
Fullerene soot (>7% wt fullerenes)	>20	1-10	-11.4*
Fullerene (refined mix, 75 % C60, 22% C70, 3% >C70)	>20	1-10	-3.1
Fullerene (purified, >99% C60)	>20	1-10	-1.1
Crystalline silica (Min-U-Sil 5)	>0.1-5 μm	1-5	-3.2
Nano alumina	45	1-10	-2
Nano TiO_2 (Anatase)	10	0.1-1	-11.4*
Fine TiO_2 (Rutile)	<5 μm	0.5-3	-1.3



Nano silver in serum mix by EM and confirmation by EDS

Comparison of the antioxidant capacities of unexposed and nanoparticle exposed serum.



CONCLUSIONS

- Determination of oxidative stress exerted by nanoparticles in human serum appears to be a valid metric in a biologically relevant sample type to screen for the potential toxicity of these novel components.
- Blood serum contains a variety of antioxidants that can quench a broad range of free radicals allowing for a system that is responsive to the presence of wide variety of free radicals and ROS/ RNS.
- The FRAP assay, used under defined conditions, is an accurate, precise and high throughput laboratory approach to screen for blood serum antioxidant damage from exposure to nanoparticles.
- The degree of oxidative stress exerted by the nanomaterials tested varied due to
  1. Particle size
  2. Impurity content
  3. and ????

PUBLICATIONS

- A high throughput analytical approach to screen for oxidative damage potential of nanomaterials in a biologically relevant system: human blood serum.
  Hsieh S-F, Bello D, Rao N, Rogers E (UML). submitted
- Exposure to nanoscale particles during CVD growth and subsequent handling of vertically-aligned CNT films
  Bello D, Hart AJ, Ahn K, Hallock M, Yamamoto N; Garcia E, Ellenbecker MJ, Wardle BL (UML & MIT), submitted
- Exposure to nanoscale particles during fabrication and machining of modern hybrid and nanocomposites
  Bello D, Hallock M, Ahn K, Yamamoto N; Garcia E, Ellenbecker MJ, Hart AJ, Wardle BL (UML & MIT), submitted
- Exposure to nanoscale silver particles associated with antimicrobial coatings
  Bello D, Ahn K, Ada E, Ellenbecker M (UML); submitted

MONITORING IN UNIVERSITY LABS

PI: M. Ellenbecker (Toxics Use Reduction Institute) Graduate RA: S. Tsai

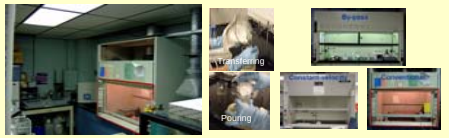
Exposure Monitoring of Airborne Nanoparticles in University Laboratories

Abstract : The Center for High-rate Nanomanufacturing (CHN) is committed to working safely with nanoparticles (NPs). As part of this commitment, we have been evaluating potential nanoparticle exposures in CHN labs and developing best practices for handling nanoparticles. We monitored airborne nanoparticle exposure at various workplaces, studied 7 different processes and 7 types of nanomaterials. In addition, since manual handling of nanoparticles is a fundamental task of most nanomaterial research; such handling may expose workers to ultrafine or nanoparticles, we evaluate the performance of 3 types of fume hoods to against nanoparticle exposure.

Equipment : Fast Mobility Particle Sizer Model 3091 (FMPS) by TSI is used to measure particles size range from 5.6 to 560 nanometers in 32 size channels with 1 sec sampling time.
Collect nanoparticles on Cu/C tapes, TEM grids and polycarbonate filters at breathing zone using filtration method.

Workplace monitoring

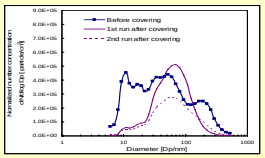
Fume hood experiments

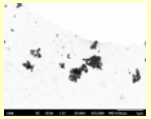


- Studied 7 NPs, 7 processes
- Measured NPs release on most processes
- Evaluate ventilation - fume hood
- Engineering controls at source reduced nanoparticle release
- Administrative controls removed background nanoparticles
  Need good work practices to reduce exposure

- Tested 3 hood types
- Leaking of NPs were found, caused by complex airflow pattern
- Exposures vary by hoods, operating conditions, worker's motions and other vaiables.
- Standard hood test allowed 0.1ppm of tracer gas release, this can have millions of NPs being released
- Solutions: need to improve practices and evaluate other new hood designs

Results of isolating feeding port of nanocomposite compounding process



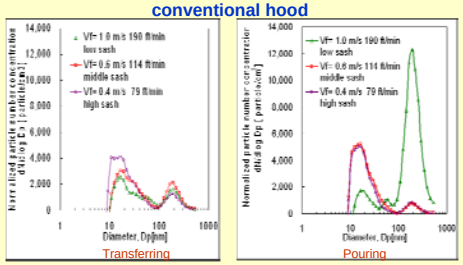


Nanoalumina particles collected at breathing zone

Publications and Presentations

- **Tsai, S.,** Ada, E., Ashter, A., Mead, J., Barry, C., Ellenbecker, M., "Control of Airborne Nanoparticles Release during Compounding of Polymer Nanocomposites," submitted to special issue of the International Symposium on Nanotechnology in Environmental Protection and Pollution 2008.
- Ashter, A., **Tsai, S.**, Ellenbecker, M., Mead, J., Barry, C., "Effects of Nanoparticle Feed Location during Nanocomposite Compounding," submitted to Polymer Engineering and Science Journal, 2007.
- Ellenbecker, M., **Tsai, C.**, Issacs, J., "Best Practices for Working Safely with Nanoparticles in University Research Laboratories," submitted to special issue of the International Symposium on Nanotechnology in Environmental Protection and Pollution 2008.
- 1 occupational hygiene paper in preparation
- 5 presentations in 5 conferences

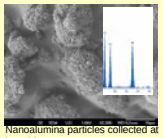
Results of handling 100 g nanoalumina in the conventional hood



Breathing zone concentration at conventional hood (background subtracted)

Publications and Presentations

- **Tsai. S.**, Ada, E., Ellenbecker, M., "Airborne nanoparticle Exposures Associated with the Manual Handling of Nanoalumina in Fume Hoods," accepted for publication, special issue of the Journal of Nanoparticle Research, 2008.
- 3 presentations in 3 conferences
- 1 presentation submitted to AIHCE
- Initiated cooperation with hood researchers in Taiwan



Nanoalumina particles collected at breathing zone

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