# What is going on "***out there***"?

# Experiences of the NTRC Field Research Team

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CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

National Institute for Occupational Safety and Health
NIOSH

## Background/Purpose:

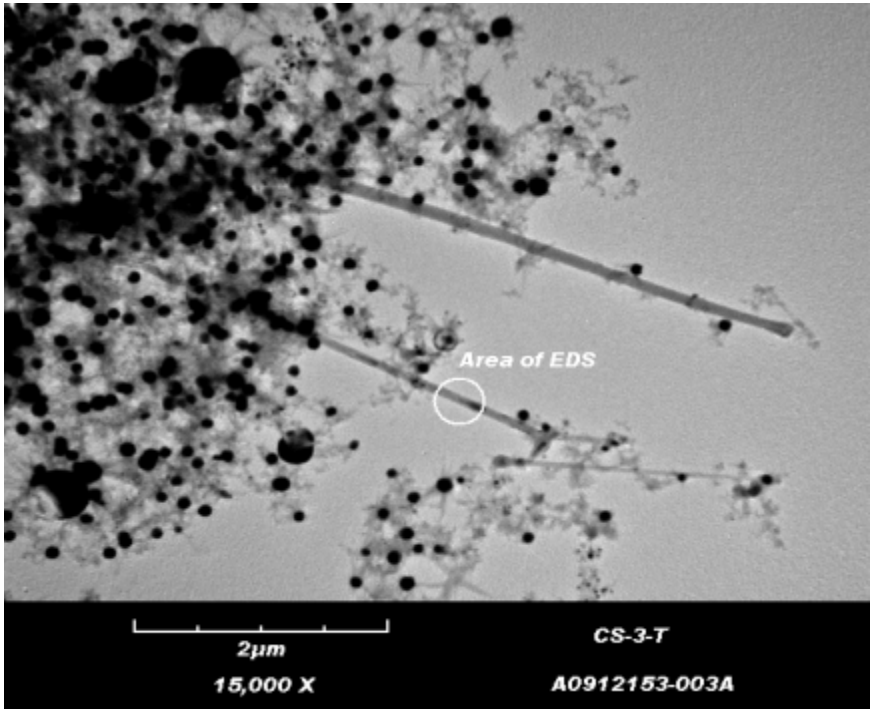
1. To conduct site assessments at a variety of facilities engaged in the manufacture, and/or handling of engineered nanomaterials.
2. Determine, using commercially available instrumentation, whether nanomaterial emissions occur during different tasks.
3. Estimate the "**potential**" for occupational exposure, on a "task-by-task" basis.

## Materials/Methods/Strategy:

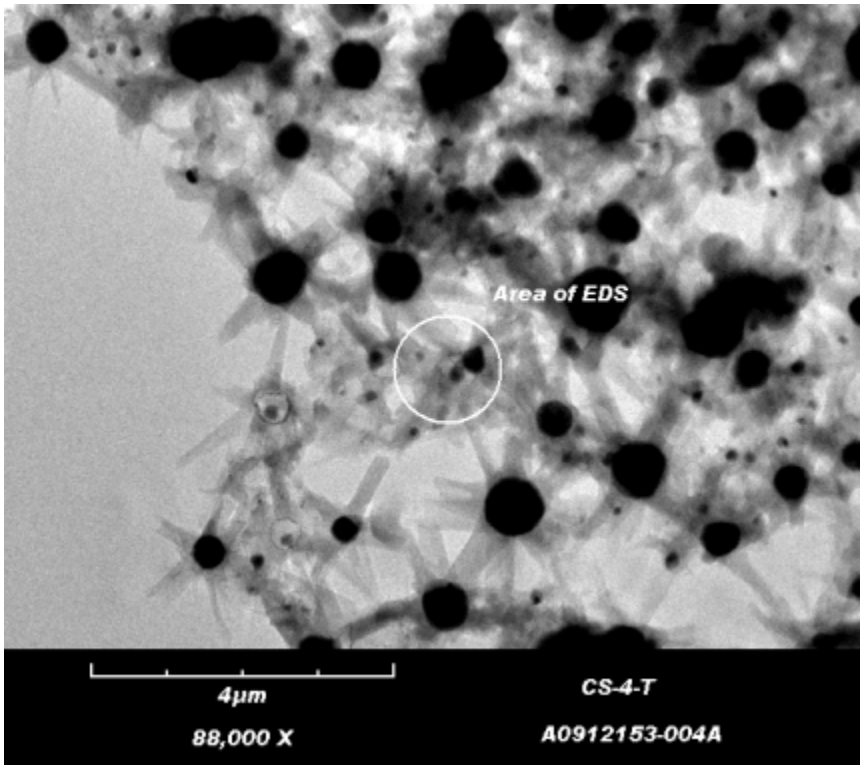
1. Use a combination of direct-reading instruments such as particle counters and aerosol photometers (CPC/ARTI/P-Trak/DustTrak) and filter-based air sampling methods (Mass concentration/TEM analysis).
2. Range-finding by design – identify opportunities to future, more detailed work.
3. Collect Task-based PBZ/"At Source (AS)"/General Area (GA) samples (Use direct-reading instruments to "sniff out" tasks that emit particulate, then conduct filter-based samples).
4. Open-faced air sampling cassettes (Mass concentration - media dependent on analyte: e.g. TEM = MCE; SEM = Polycarbonate; Elemental Carbon = Quartz).
5. Examine all tasks that involve engineered nanomaterials. "Evaluate each piece of the system"
6. Compare tasks, on a relative basis, to identify high potential for exposure.

Harvesting SWCNT's from a Carbon Arc Reactor

Task-based PBZ air sample analyzed via TEM w/ EDS



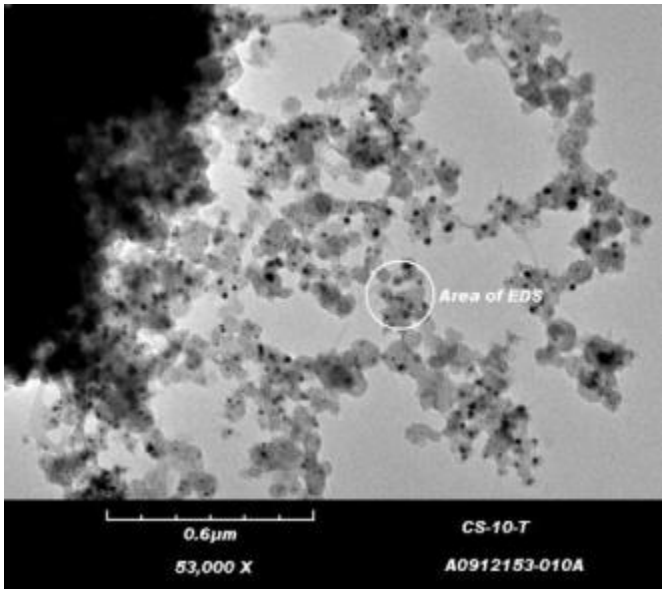
Harvesting SWCNT's, scraping product from wall of Carbon Arc Reactor




Task-based "At source" air sample

Manual transfer of SWCNT's to trays prior to transfer to blender used for homogenization

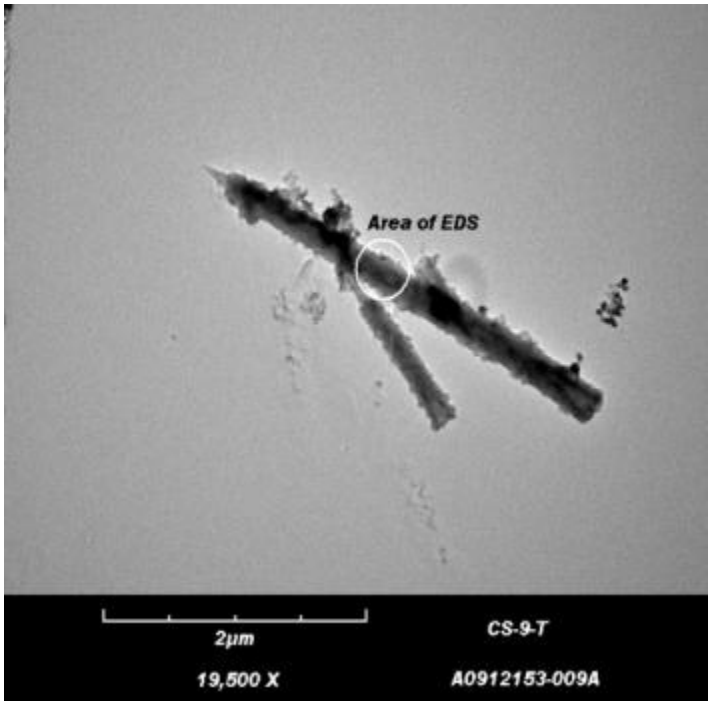
TEM image of AS sample Collected during transfer to blender



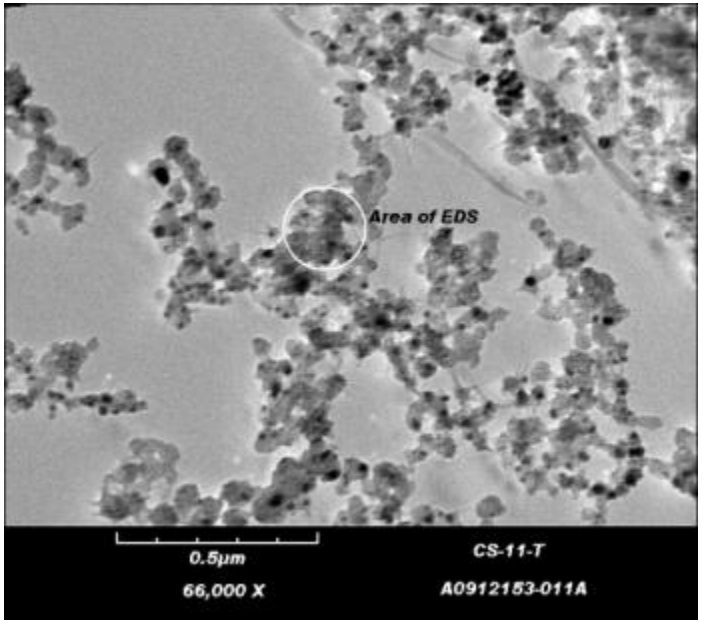
Use of a HEPA vacuum for cleaning of residual SWCNT's and soot inside Carbon Arc Reactor

Custom-fabricated powder transfer device

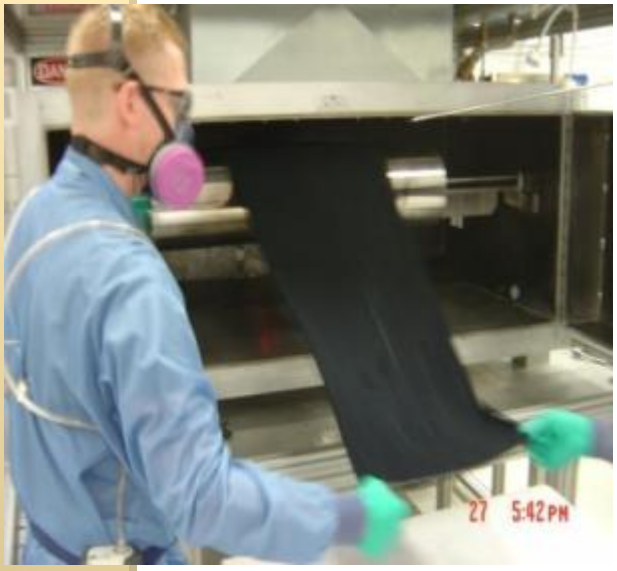
PBZ sample during weighing




AS sample during weighing

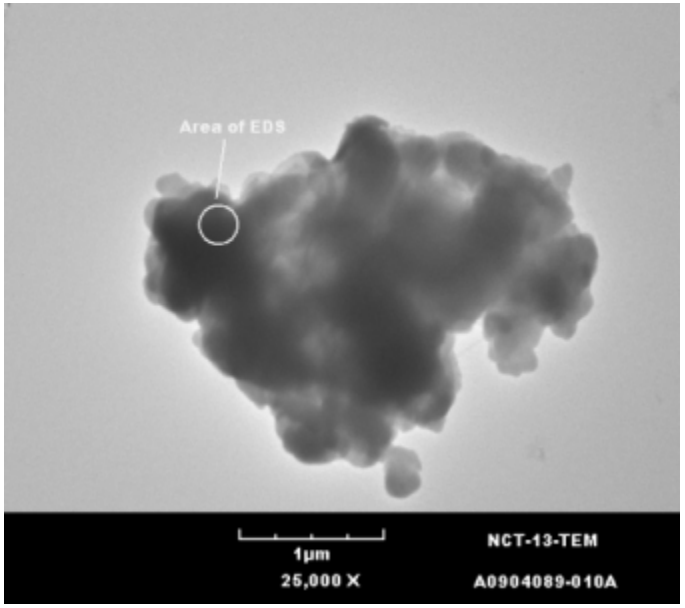


Example of mfg making CNT sheet and yarn material – Processes enclosed and ventilated



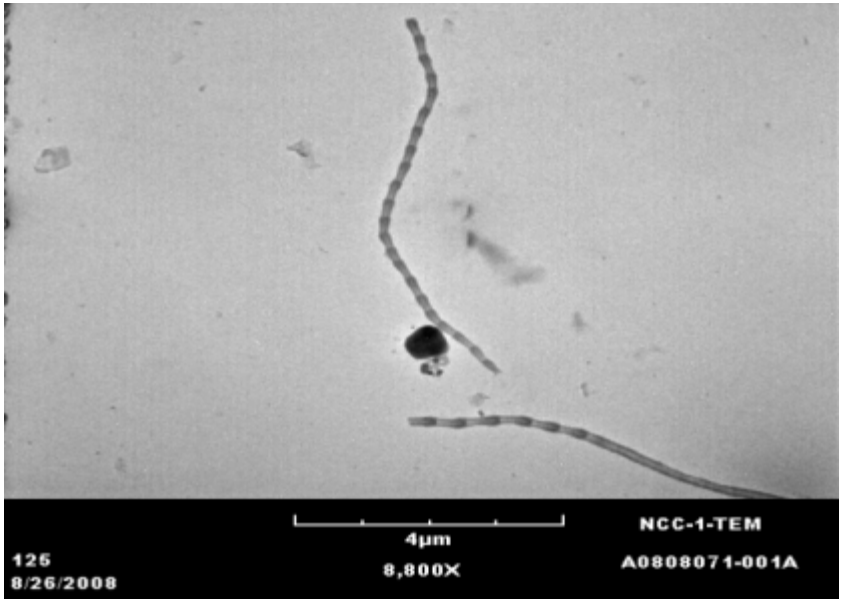
Harvesting sheet material

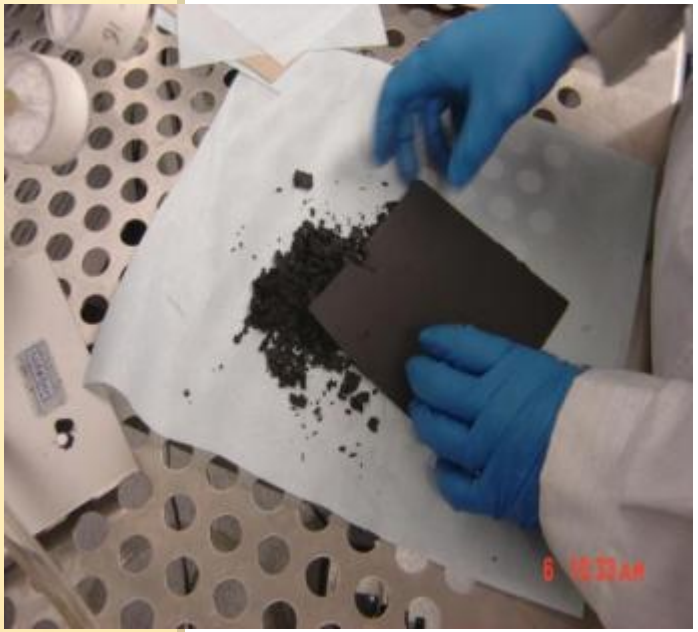
PBZ during harvest – no tubular structures present, material considered amorphous carbon soot



Weighing small quantity of CNF's inside ventilated balance enclosure

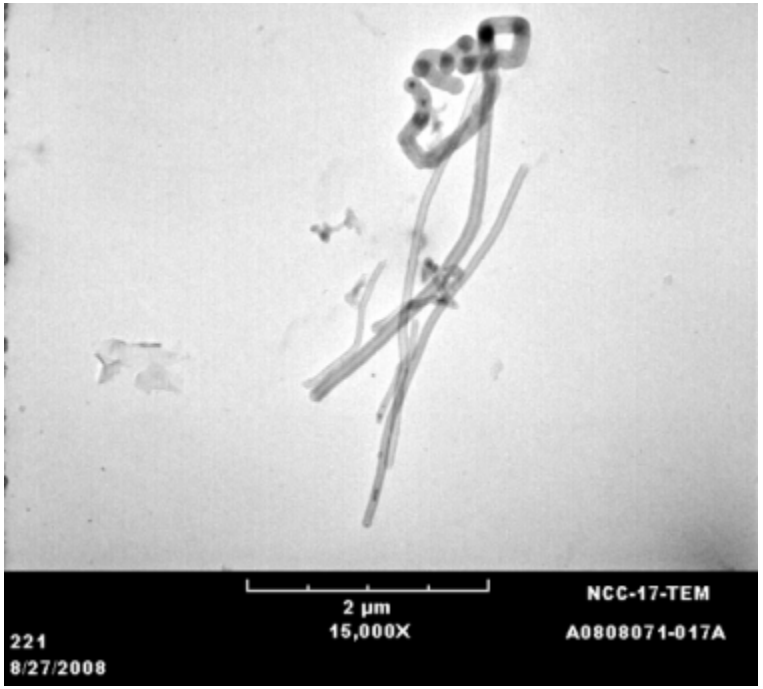
PBZ shows CNF's can escape ventilated enclosure!

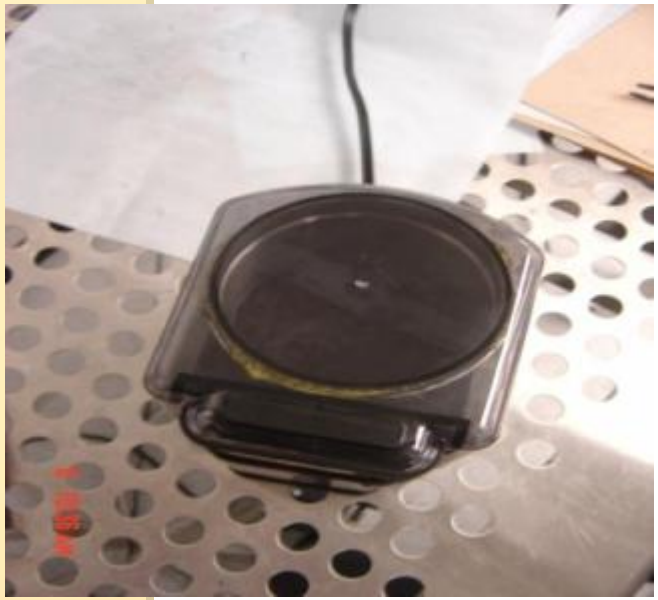




Crumbling "Buckypaper" made of CNF's on benchtop

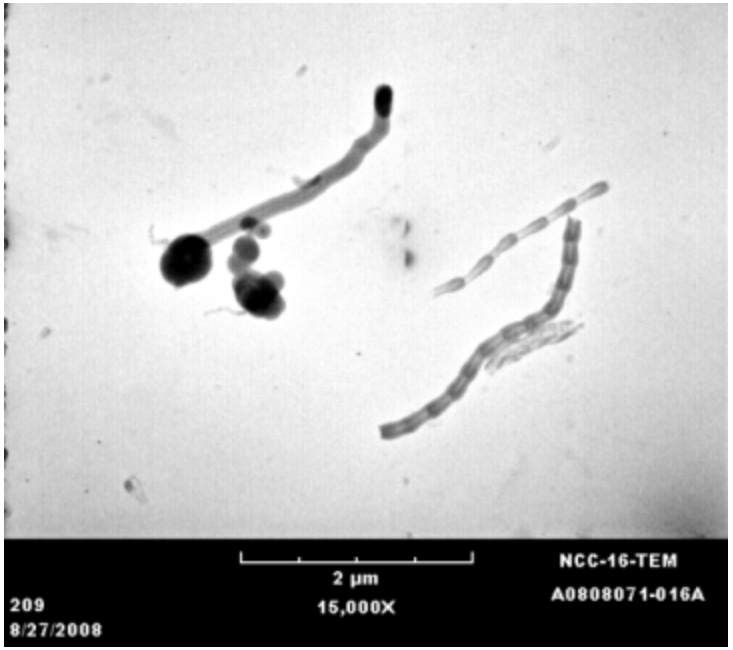
AS sample indicates CNF's released to lab atmosphere





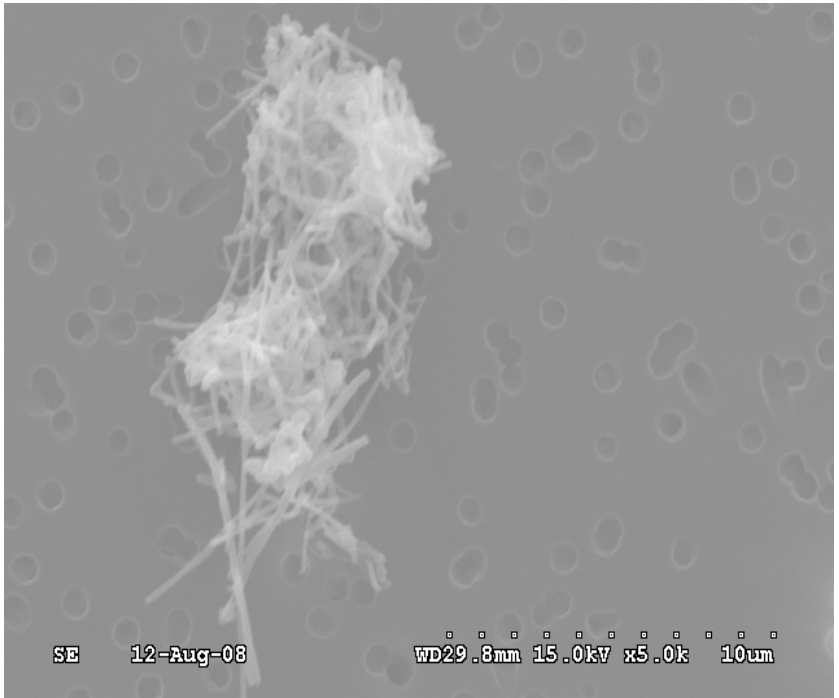
"Coffee bean grinder" used to homogenize crumbled Buckypaper

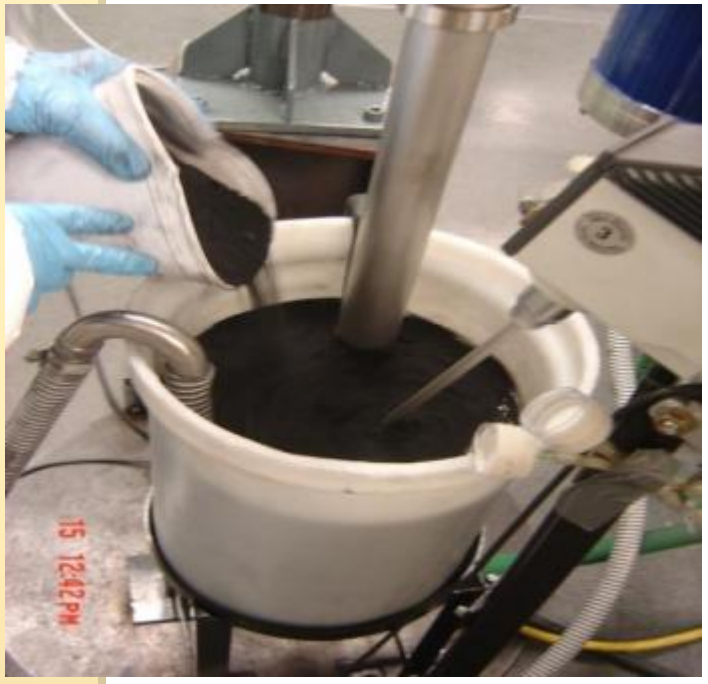
AS sample near lid of grinder indicates release occurred



Weighing MWCNT's

PBZ sample collected on a polycarbonate filter and analyzed by SEM



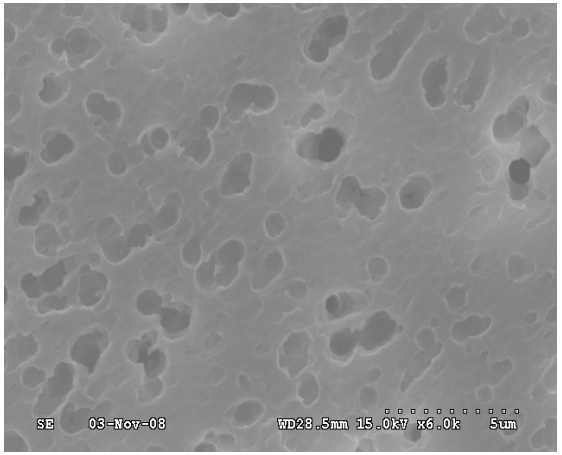



Adding MWCNT's to vortex mixer

AS sample shows release occurred

Concern about release of MWCNT's out drying oven exhaust

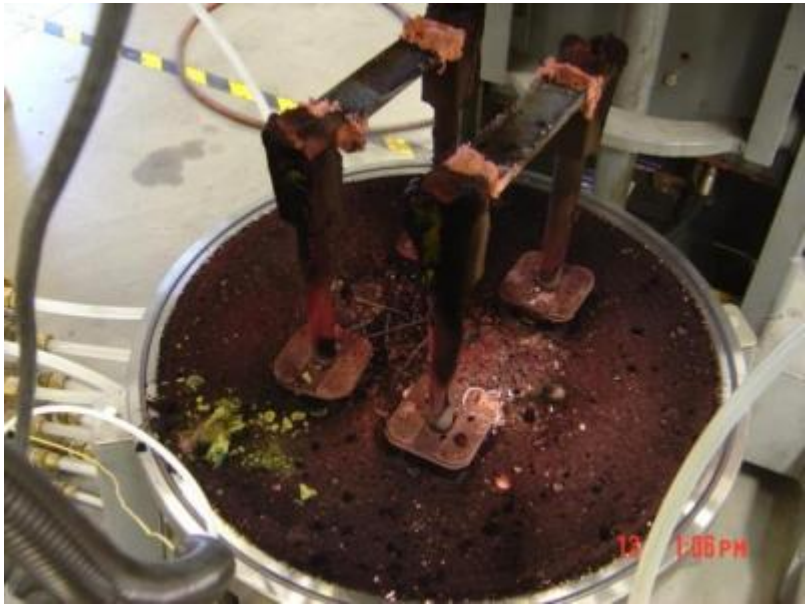
No MWCNT's detected



HEPA filtered “air shower” used to remove particulate resident on clothing. Interlock design ensures worker uses each time he enters/exits work area.

Metal oxide reactor
– Condensation Vapor Deposition

**Problem**: buildup of slag and waste material

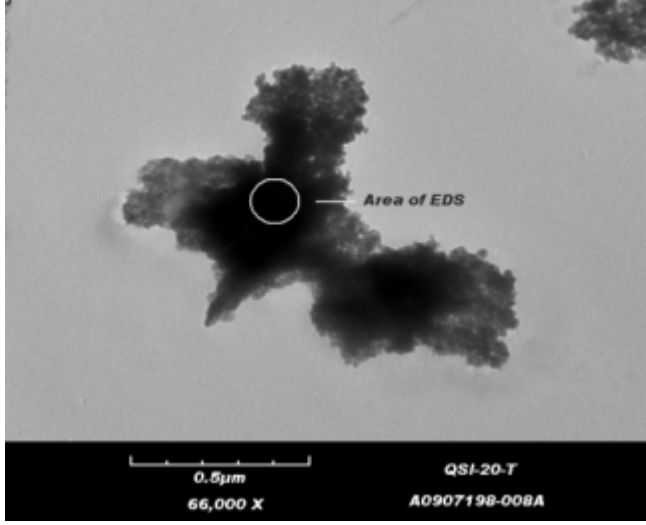


Tools used to clean reactor

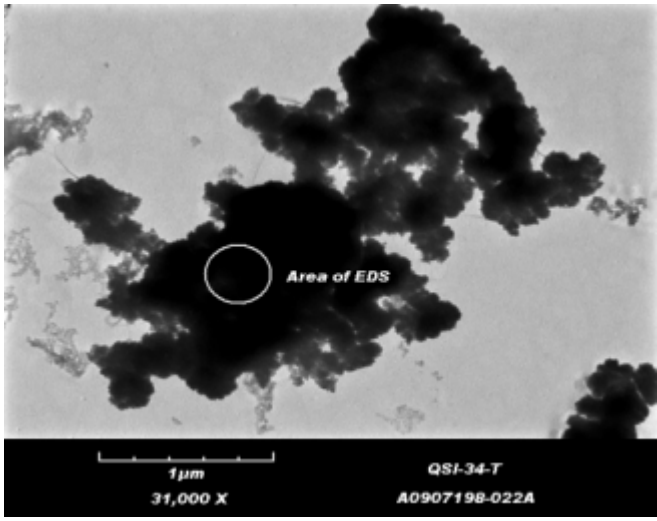
Vigorous manual brushing/scraping necessary to get reactor clean

Recommended use of LEV to reduce emissions during reactor cleanout. Designed custom-fit flange to improve capture efficiency

Dramatic reduction in PBZ mass and particle number concentration when LEV used during reactor cleanout



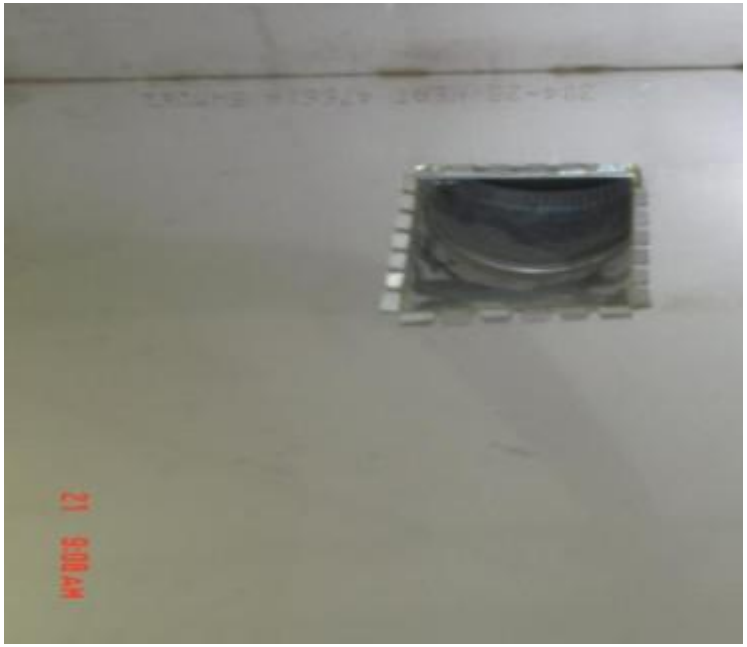

PBZ with LEV




PBZ no LEV

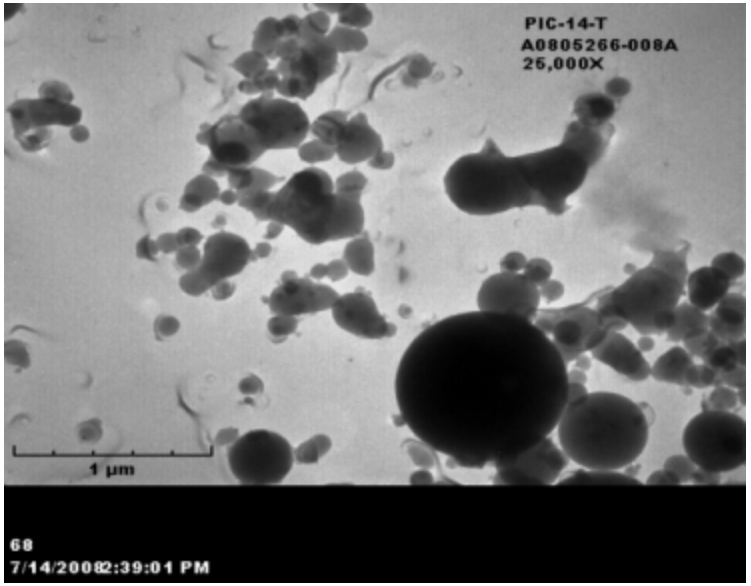
Nano alumina reactor

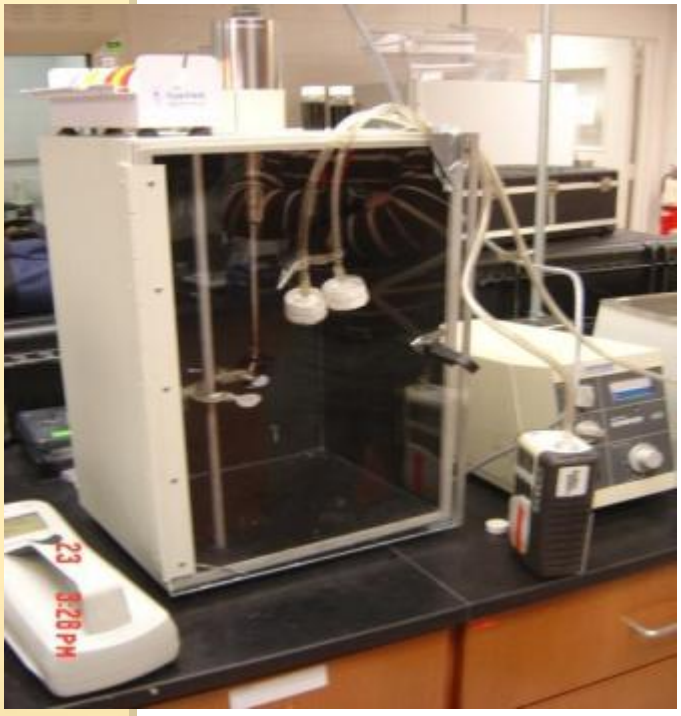
Sole source of exhaust ventilation (6 inch duct) for room that housed entire reactor/process equipment



Cleanout/brush-down reactor

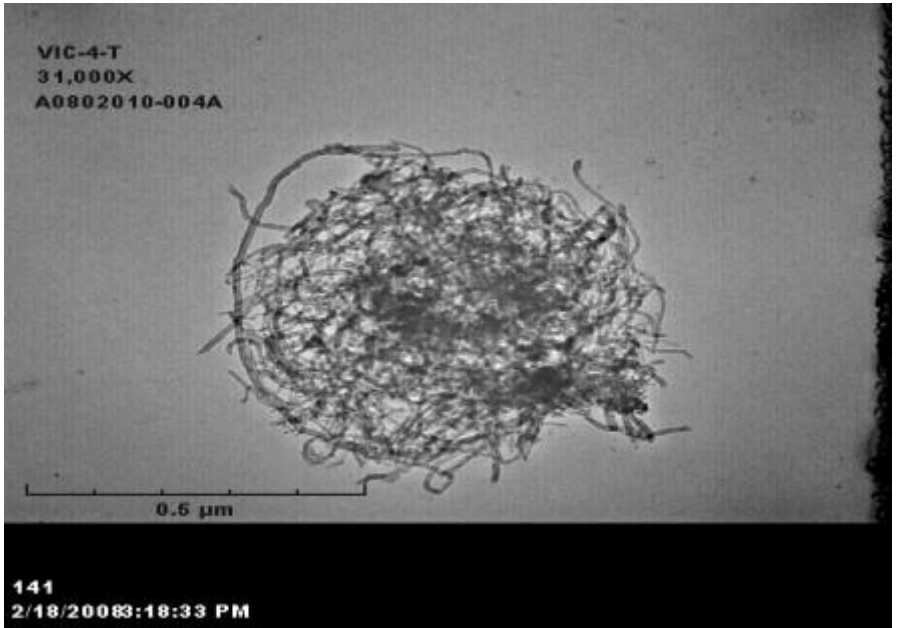
PBZ sample during cleanout





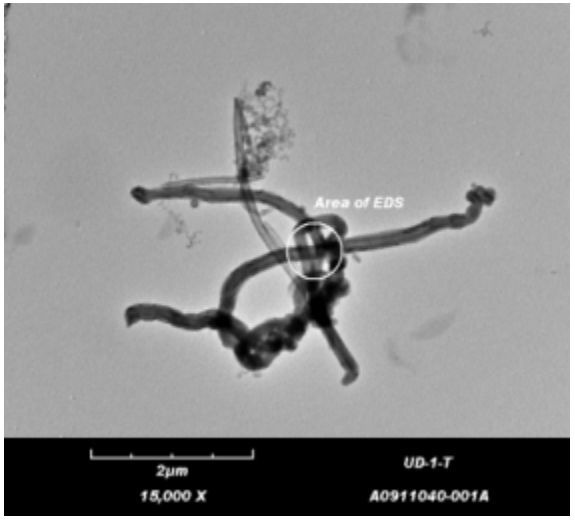
Probe sonication of water containing CNT's

AS sample indicated water droplets ejected from vial during sonication carried CNT's ! !



Weighing CNF's inside lab hood

PBZ indicates CNF's reach breathing zone and could escape and contaminate adjacent areas/entire lab

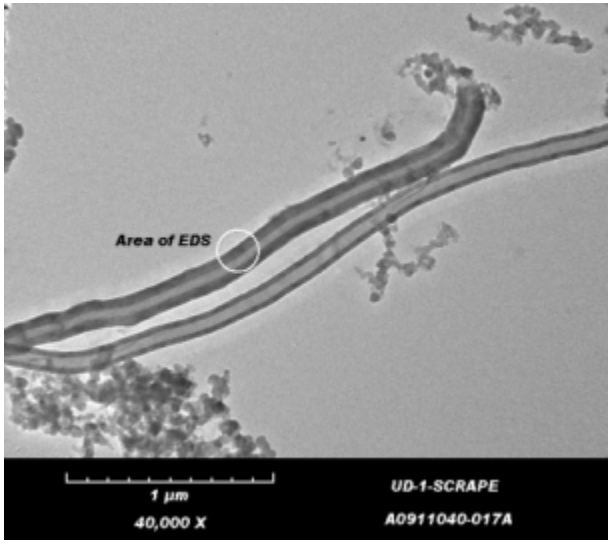


Inadequate hand/wrist protection

Dermal exposure

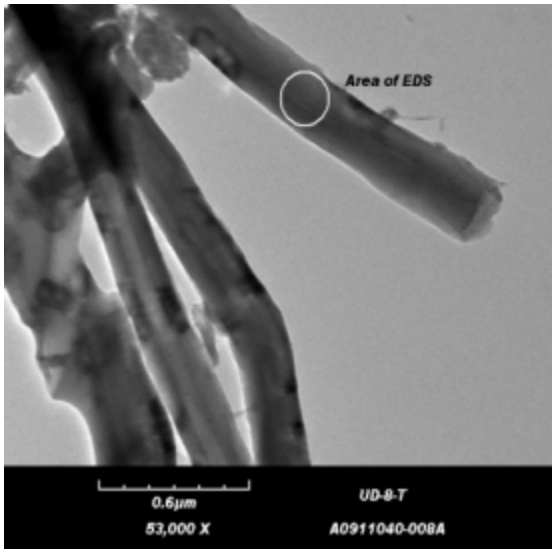
Lab hood exhaust duct leakage

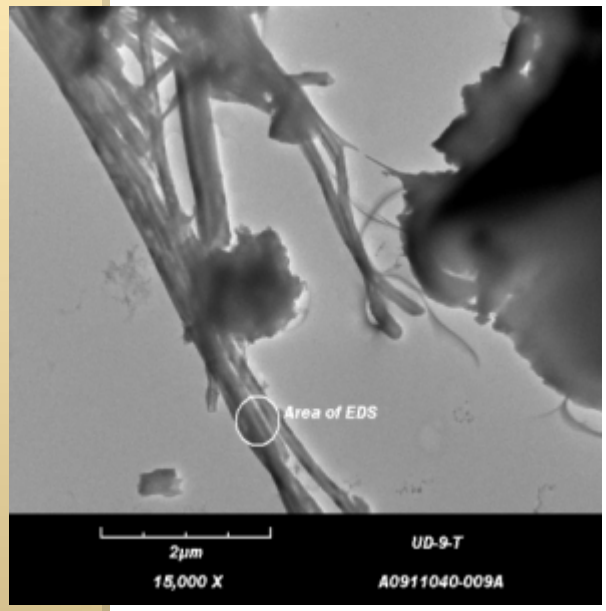
Took scraping of dark material and examined via TEM



Wet saw cutting of CNF composite material

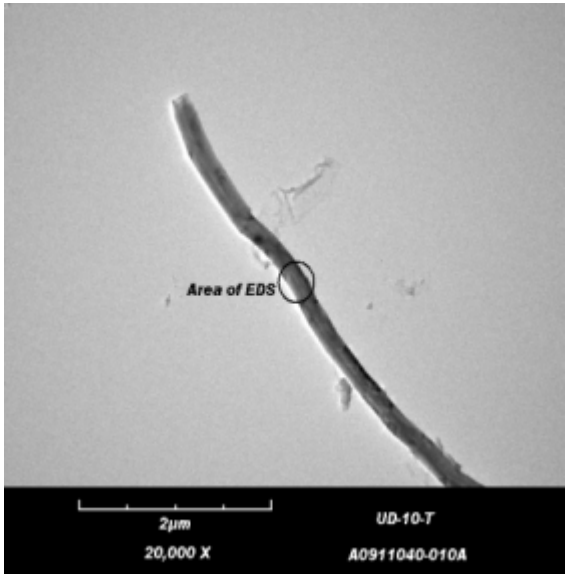
PBZ sample during wet saw cutting



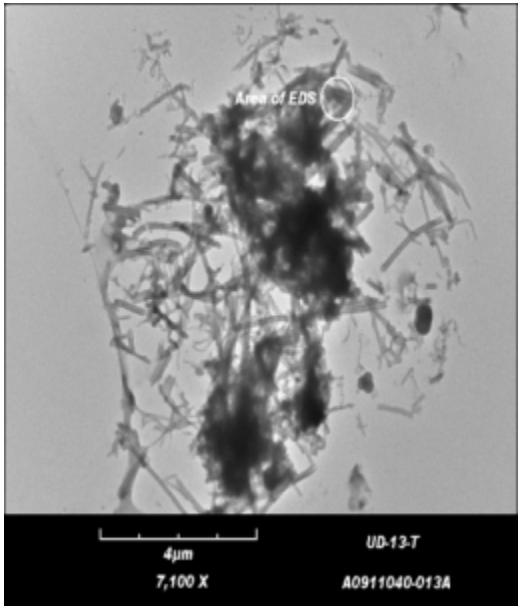

Inside enclosure

Outside enclosure



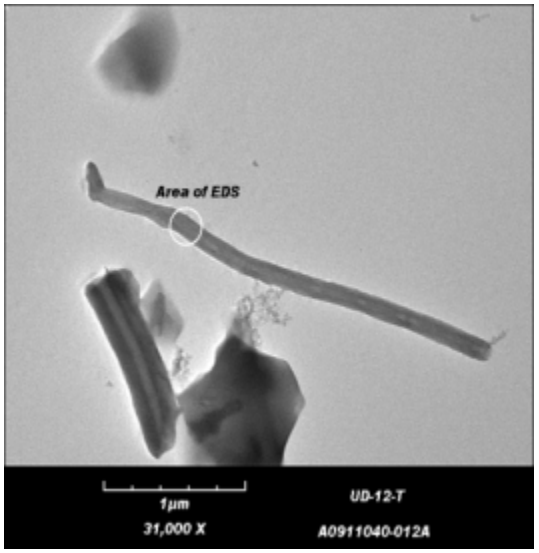
Surface grinding of CNF composite w/ LEV

PBZ during surface grinding w/ LEV



LEV inlet positioned 90 degrees from direction of plume exiting wheel – greatly reduced capture efficiency

AS sample located just above LEV inlet – indicates less than optimum capture



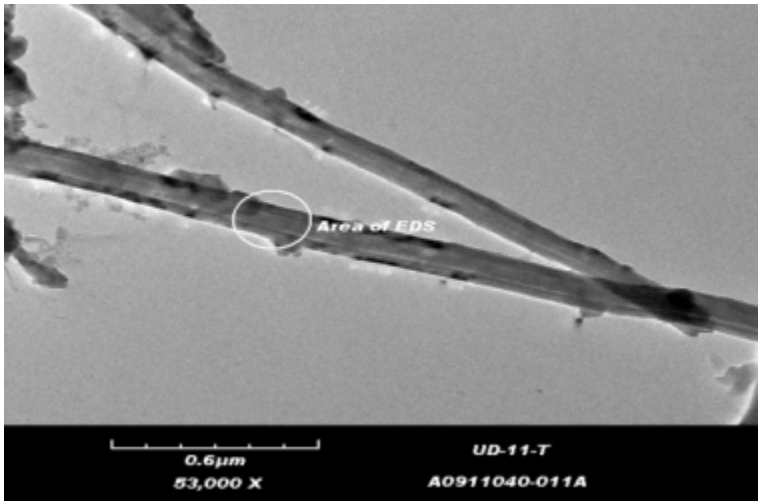
Unique application of LEV…

Tensile testing of CNF composite material

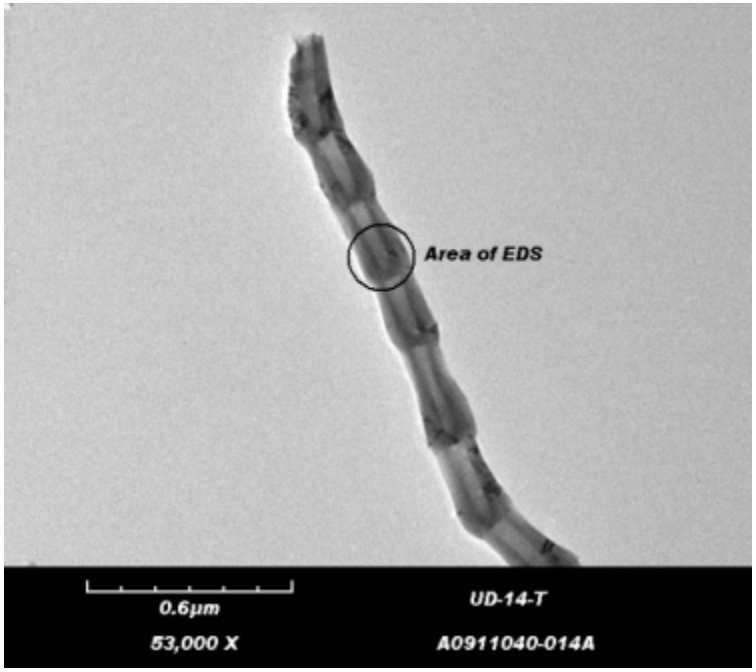
Notice darkened area on wall directly behind saw – was found to be due to droplet plume spun off from rotation of diamond blade

Table saw with diamond blade used to cut CNF composite

PBZ

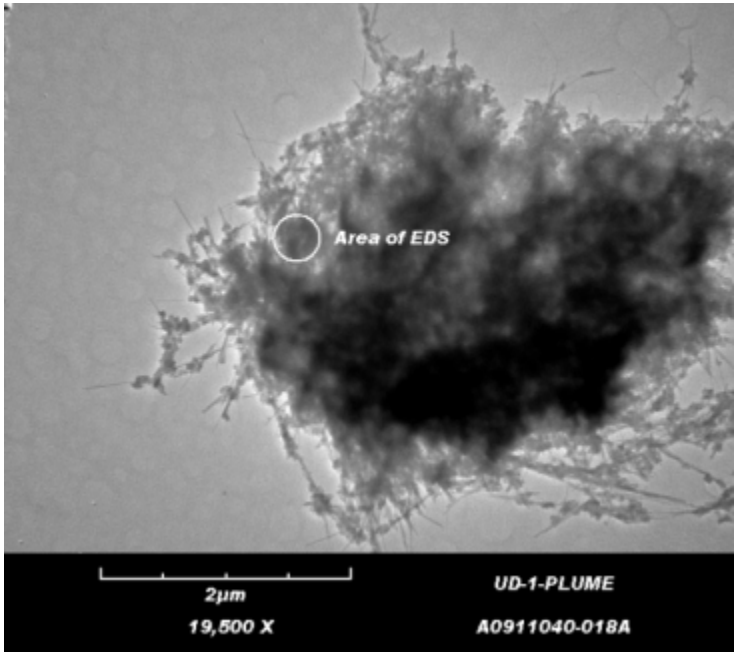


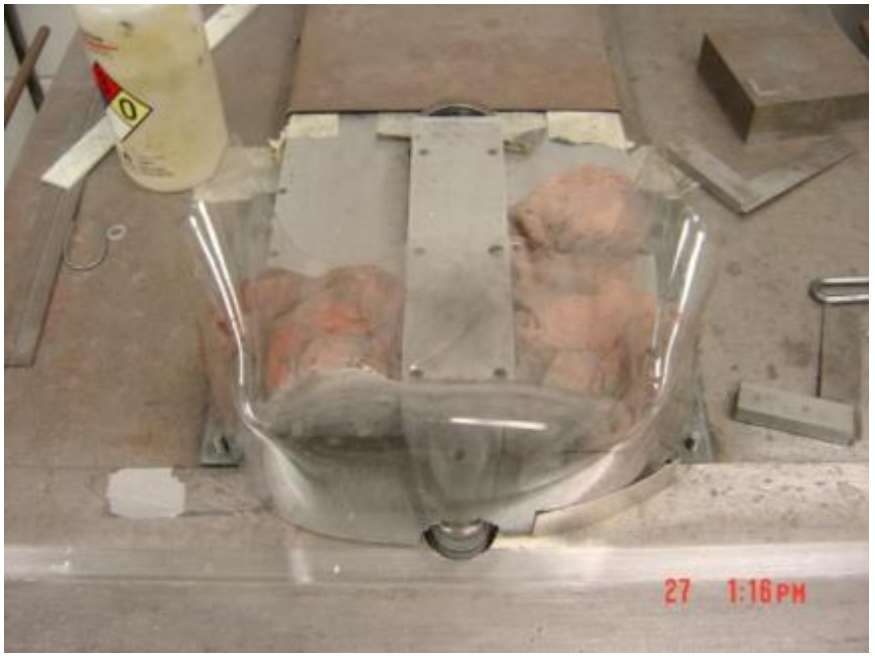
General area



Droplet plume deposition onto unprotected skin during wet saw cutting of CNF composite

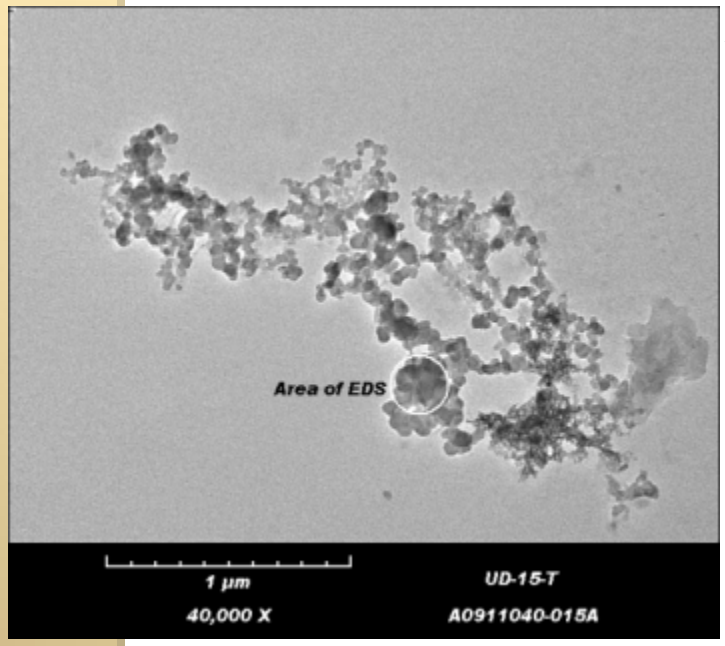
TEM of droplet plume emitted from diamond saw blade during wet saw cutting of CNF





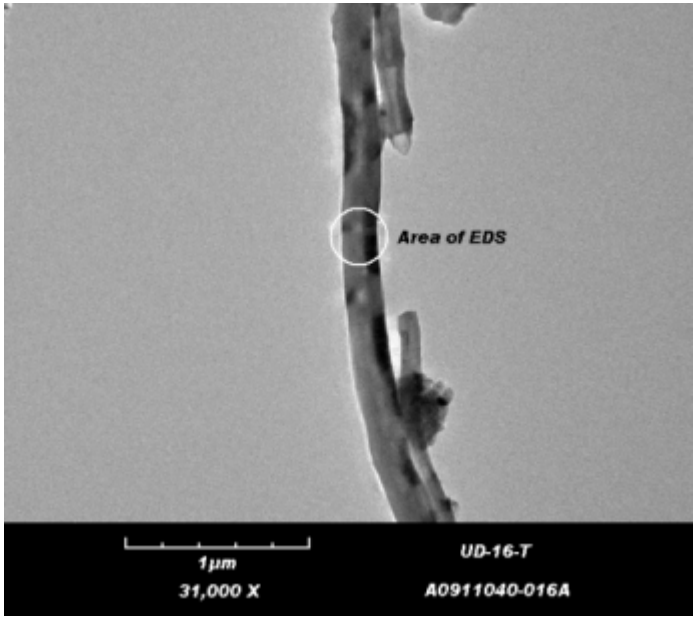
Some “unique” enclosure/LEV designs

Belt sanding of CNF composite




PBZ

AS

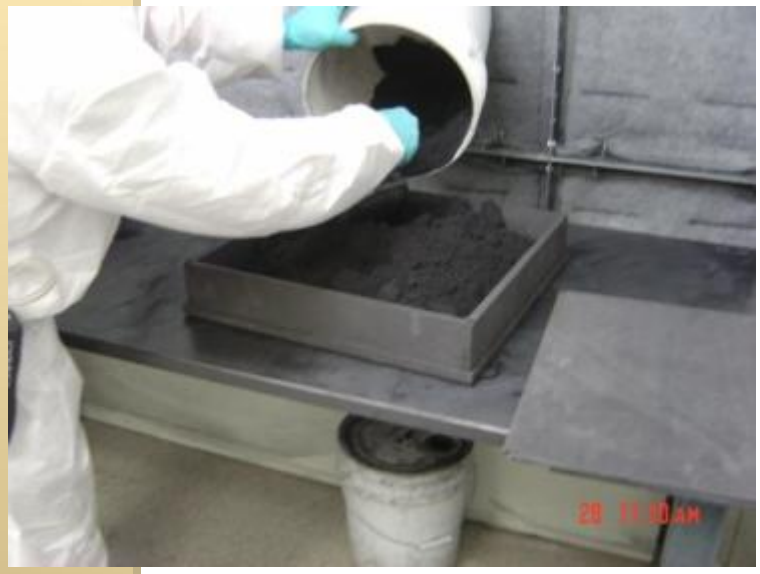


Raw material (CNF's) prior to being transferred to graphite trays for heat treating

Ventilated walk-in booth for CNF transfer to graphite trays

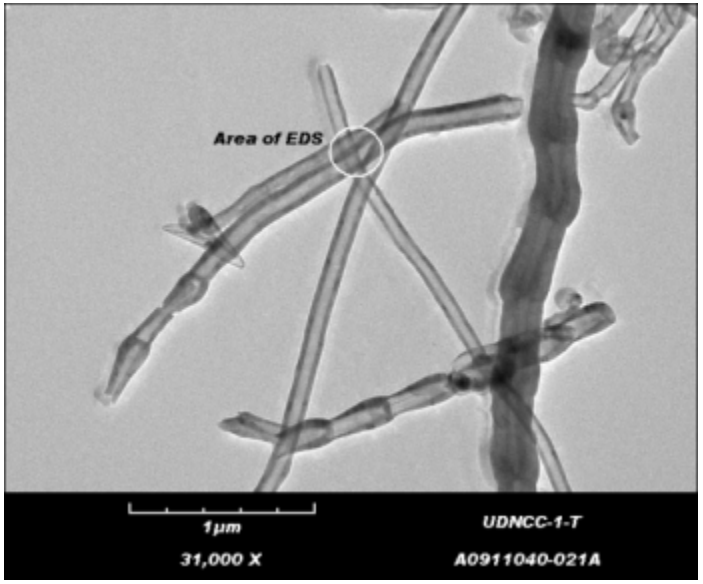
Two methods of clean up – HEPA vacuum and Leaf Blower

Darkened floor area due to grinding CNF into resilient floor tile with footwear



Loading tray w/ CNF's

PBZ



Using HEPA vac to clean outer surface of trays of spilled material

Dark specs are clumps of raw CNF's that accumulate during tray loading

"Sticky mats" are used at the exit of the tray loading room – This mat was changed prior to transporting trays to the furnace area. This accumulation is due to 6 trips out to the furnace.

## Summary:

1. To date, 31 site assessments have been performed.
2. A variety of nanomaterials have been studied.
3. A variety of controls have been observed, with varying degrees of effectiveness.
4. Different types of Personal Protective Equipment (PPE) have been used.
5. Specific tasks were identified as substantial contributors to "**potential** "exposure.
6. Emissions and subsequent "**potential**" exposure do occur.
7. Electron microscopy is a key tool to "visualizing" the characteristics (size, morphology, degree of agglomeration) of emitted nanomaterial.
8. Follow-up studies to evaluate interventional controls (e.g. LEV) have been performed: Result = reduction in emissions to the workplace atmosphere.

## Future work:

1. Nanomaterial Exposure Limits need to be established so facilities can determine actual full-shift worker exposure for compliance purposes.
2. More detailed personal exposure assessment studies need to be conducted at facilities identified as having "potential" exposure.
3. Guidance on validated/field tested methods and instrumentation (both analytical and Industrial Hygiene sampling) is needed.
4. Engineering control effectiveness studies are needed so that guidance can be offered to facilities wishing to reduce/eliminate exposure.