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Recent Government Briefs

New National Toxicology Database Records on Nanomaterials

The National Library of Medicine (NLM) has recently added a set of nanomaterial records to its Hazardous Substances Data Bank (HSDB). The HSDB is a publically available database that provides toxicology information on human exposure, environmental fate, and regulatory requirements for over 5,000 different chemicals. The database is populated with information from books, government documents, technical reports, and selected primary literature. The information contained in each record is subject to peer-review by a committee of experts familiar with the subject material. Similar to the existing records in the HSDB, the nanomaterial records contain information on toxicity, manufacturing and use, chemical and physical properties, and environmental fate and exposure. There are currently seven HSDB nanomaterial records (carbon nanotubes, fullerenes, silver nanoparticles, iron nanoparticles, titanium oxide nanoparticles, zinc oxide nanoparticles, and cerium oxide nanoparticles). In addition to the seven records, information on hollow, spherical or ellipsoidal carbon nanostructures may be found in the fullerenes record, and information on tubular or lattice materials may be found in the carbon nanotubes record.

The HSDB and nanomaterial records are available at: <http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB>

US EPA Proposes a Second SNUR for Multi-Walled Carbon Nanotubes

As we described in a previous of our newsletter [Link], on November 6, 2009, the US Environmental Protection Agency (US EPA) published a proposed significant new

use rule for multi-walled carbon nanotubes (MWCNTs) under Section 5(a)(2) of the Toxic Substances Control Act (TSCA) for anyone intending to manufacture MWCNTs. Similarly, on February 3, 2010, the US EPA published a second proposed SNUR for MWCNTs, which would require individuals who also import or process MWCNTs for any significant new use to notify US EPA at least 90 days prior to the activity. This would provide US EPA an opportunity to evaluate the intended use and, if necessary, to prohibit or limit the activity before it occurs. Comments for this second proposal are due by March 5, 2010.

The US EPA "Proposed Significant New Use Rule for Multi-walled Carbon Nanotubes" (40 CFR Part 721 [EPA-HQ-OPPT-2009-0686; FRL-8796-7]) may be viewed in its entirety at:

<http://www.regulations.gov/search/Regs/contentStreamer?objectid=0900006480a8c7eb&disposition=attachment&contentType=html>

Manufacturers of Carbon Nanotubes in California Respond

The state of California (CA) has recently made available the responses to the Department of Toxic Substances Control (DTSC) formal request for information from manufacturers of carbon nanotubes (CNTs). The DTSC defines manufacturers as those who produce or import carbon nanotubes (CNT) in the state of CA, including academic institutions doing CNT research, and those manufacturers who are involved in producing or importing CNTs in their chemical form. In a January 2009 letter, the DTSC requested information on what products CNTs are used in; what sampling, detection and measurement methods are employed; what end-of life disposal methods are employed; what personal protective equipment is used; and is the discarded material produced by the manufacturer treated as a hazardous waste. According to DTSC, this information will be used in future assessments of environmental and human health risk. As of the publication of this newsletter, 16 of 24 organizations, representing government agencies, universities, and industry have complied with this information request. The letters are publically available on the Nanomaterials Information Call-In web page.

Submitted Information for the Carbon Nanotube Information Call-in is available:

<http://www.dtsc.ca.gov/TechnologyDevelopment/Nanotechnology/nanocallin.cfm>

Reports, Reviews, White Papers, and Books

Nanomaterials and Immune Function

C. Chang

Link: <http://www.ncbi.nlm.nih.gov/pubmed/19995678>

A recent paper in the Journal of Autoimmunity by Christopher Chang, of the School of Medicine at the University of California at Davis, reviews how *in vitro* and *in vivo* studies are showing how nanoparticles (as well as ultra fine particles; UFP) may be activating proinflammatory cytokines, chemokines, and adhesion molecules by recruiting a number of inflammatory cell types (e.g., basophils, macrophages, dendritic cells, T cells, neutrophils and eosinophils). Chang describes how these changes may affect immune defense as well as non-immunologic functions. He also describes how the immune system damage can lead to autoimmune, allergic and even neoplastic disease states. Chang reviews many of the current applications of nanoparticles and how these materials are being used in virtually all industries (e.g., food science, genetic engineering, cosmetics, applied physics, device physics, health, textile, materials science, colloid science, and chemical, mechanical, biological, and electrical engineering). While nanoparticles are similar in size to many ambient ultrafine particles, Chang states that the risk of nanomaterials may be much lower due to the more homogeneous nature of nanoparticle preparations. Chang notes that further research is needed to establish safe exposure levels for this important new class of particulates.

Nanotoxicology and Nomenclature

R. Aitken, P. Borm, K. Donaldson, G. Ichihara, S. Loft, F. Marano, A. Maynard, G. Oberdörster, H. Stamm, V. Stone, L. Tran, H. Wallin

Link: <http://www.informahealthcare.com/doi/full/10.3109/17435390903337701>

A recent paper in the journal Nanotoxicology is focused on how the term “nanoparticles” is used indiscriminately in the titles of peer-reviewed scientific papers, and how this affects the perception of risk when these papers are described by the popular press (i.e., newspapers, television, radio, etc.). For example, the 12 authors of this review describe the 2009 paper published in the International Journal of Toxicology by Song *et al.*, entitled “Exposure to nanoparticles is related to pleural effusion, pulmonary fibrosis and granuloma.” The authors claim that the title of this particular paper is dangerously misleading as it draws a premature causal link between exposure to nanoparticles and observed health effects. These types of titles, once captured in press-releases, tend to propagate a myth that all nanoparticles are dangerous. According to the authors, this practice may mislead the “public and the media into believing there is some reason to fear nanoparticles.” As such, the authors caution all scientific writers to “ensure that all descriptions of nanoparticle hazards recognize the intrinsic heterogeneity of the nanoparticle hazard and discuss the uncertainty of alleged causality; ensure that there is a convincing and scientifically sustainable link between any nanoparticle exposure and any pathological outcomes putatively associated with that exposure; and, ensure that sufficient physical and chemical characterization data are provided on the nano-

particles in question to support valid data interpretation and comparison.”

“Nanotoxicity: *In Vivo* and *In Vitro* Models to Health Risks”

S. Sahu, D. Casciano

Link: <http://www.wiley.com/WileyCDA/WileyTitle/productCd-0470741376.html>

Saura Sahu of the US FDA and Daniel Casciano of the University of Arkansas Medical Center have recently edited a book entitled “Nanotoxicity: *In Vivo* and *In Vitro* Models to Health Risks.” This book, published by John Wiley & Sons, Ltd. (ISBN 978-0-470-74137-5), covers recent information regarding the safety evaluation of nanomaterials in foods, drugs, medical devices, cosmetics and other regulated products. Examples of topics covered in over 600 pages of this book include: biomarkers for nanotoxicity assessment; nanotoxicity assessment by gene expression analysis; *in vivo* and *in vitro* models for nanotoxicity testing; biological mechanisms of nanotoxicity; pharmacokinetics of nanomaterials nanotoxicology of foods, drugs, and cosmetics; health and environmental impacts of nanomaterials; safety evaluation of nanomaterials; and the implications of nanomaterials for regulatory decision making. According to Sahu and Casciano, the purpose of this 26 chapter book was to assemble current, state-of-the-art toxicological information on nanomaterials from recognized experts in a single volume. The result is a contemporary source of knowledge in nanotoxicology. While many chapters of this book will be of interest to research scientists that are currently engaged in laboratory research, much of this book will also be of interest to applied scientists including toxicologists and risk assessors evaluating the potential health risks of nanomaterials in environmental media, food, drugs, and consumer products.

Upcoming Meetings and Conferences

2nd NanoImpactNet Conference

March 9-12, 2010, Lausanne, Switzerland

Link: http://www.nanoimpactnet.eu/object_class/nano_lausanne2010conference.html

Hosted by a consortium of 24 leading European academic and government research groups, the 2nd NanoImpactNet Conference will consist of two parts: a one-day training session on handling protocols for nanomaterials, and a three-day conference consisting of five sessions. Topics that will be covered in the sessions include the interactions between nanomaterials and biological, environmental, and physical barriers; quality control in nanomaterial research; and the development of policy from research. Conference attendees will include representatives from academia, industry, regulatory bodies, and the public.

8th International Conference and Workshop on Biological Barriers – *In Vitro* Tools, Nanotoxicology, and Nanomedicine

March 21-April 1, 2010, Saarbrücken, Germany

Link: http://archiv.uni-saarland.de/de/organisation/zentrale_einrichtungen/kwt/messen/biological-barriers2010

Aimed at students, academic professionals, and industry representatives, the conference will cover the potential applications and challenges of nanomedicine, the nanotoxicological implications of the use of nanomaterials, and the tools available for analyzing the interaction between nanoparticles and biological barriers. The conference, consisting of seminars, lab courses, and poster presentations, is co-organized by MediTrans, a nanomedicine project under the auspices of the European Commission's Seventh Framework Programme (EC FP7), and the Controlled Release Society's German Chapter.

13th Annual Nanotech Conference & Expo 2010

June 21-25, 2010, Anaheim, CA

Link: <http://www.techconnectworld.com/Nanotech2010/>

Coordinated by the Nano Science and Technology Institute (NSTI), Nanotech Conference and Expo 2010 is the largest nanotechnology conference in North America, hosting 350 exhibitors and 5,000 international attendees from industry, academia, research labs, and government agencies. The conference is divided into seven symposia, each of which will focus on a set of issues related to nanomaterials, including fabrication, advanced materials, electronics and microsystems, energy and environment, and investment opportunities. Within the energy and environment symposium, environmental safety and health, remediation, toxicology, neurotoxicology, monitoring, and societal issues will be discussed.

Nanomaterials and Worker Health: Occupational Health Surveillance, Exposure Registries, and Epidemiologic Research

July 21-23, 2010, Keystone, CO

Link: <http://www.cdc.gov/niosh/topics/nanotech/keystone2010/>

The National Institute for Occupational Safety and Health (NIOSH) and the Mountain and Plains Education and Research Center are hosting a three-day conference for members of the occupational safety and health community. In a combination of breakout sessions and poster and paper presentations, attendees will identify gaps in information and address issues related to occupational health surveillance, exposure registries, and epidemiologic research involving nanotechnology workers. The conference will cover: the challenges of understanding, predicting, and managing potential safety and health risks to workers in the nanotech industry; the effects of air pollution and ultrafine particles on human health; nanomaterial disposal; and precautionary control measures for nanomaterial manufacturers, users, and distributors.

Hot-off-the-Presses Peer-Reviewed Research Articles of Note

1. Johnson, DR; Methner, MM; Kennedy, A; Steevens, JA. 2010. "Potential for Occupational Exposure to Engineered Carbon-Based Nanomaterials in Environmental Laboratory Studies." *Environ. Health Perspect.* **118(1):49-54.**

Abstract: <http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.0901076>

Synopsis:

- Studies on workplace and ambient air exposures to nanomaterials are still in their nascent stages, and data on airborne exposures from laboratory and workplace practices thus remain scarce. One of the more common laboratory practices involves the preparation of liquid suspensions of nanomaterials, which are believed to pose a lower inhalation risk than powdered and other dry nanomaterials. However, to prevent agglomeration and create a well-dispersed aqueous suspension of nanomaterials, researchers often use sonication techniques or surfactants such as natural organic matter. It is hypothesized that sonication of well-dispersed nanomaterial may result in increased aerosol formation, and thus potentially increased inhalation exposures to airborne nanomaterials.
- The aim of the study was to assess the release of airborne nanomaterials during routine laboratory operations. C₆₀ fullerenes, carbon black, raw (non-functionalized) multi-walled carbon nanotubes (MWCNT), and functionalized MWCNT (*i.e.*, hydroxylated; MWCNT-OH; hydrophilic) were used in a preliminary set of laboratory experiments. Two laboratory processes were conducted: (1) weighing the nanomaterials on an electronic balance and transferring them to a mixing beaker; and (2) sonicating an aqueous suspension of the nanomaterials. C₆₀ fullerenes and carbon black aqueous suspensions were prepared in distilled water (*i.e.*, without natural organic matter), while MWCNT suspensions were prepared in the presence of 100 mg/L natural organic matter. The weighing and the transfer process was conducted inside a laboratory safety hood, with the glass enclosure to the hood half-open and the air circulation turned off. The sonication process was conducted inside an unventilated (*i.e.*, closed) chamber. Handheld particle counters were placed in both the hood and the chamber close to suspected points of emission, and filter-based air samples were used to collect particles for morphological analysis by transmission electron microscopy (TEM). Background particle number concentrations were determined prior to each experiment.
- Airborne concentrations of the nanomaterials (expressed as number of particles/L) were observed to increase as a result of weighing and handling processes. In some cases, particle number concentrations were 4-10 times higher than background concentrations. Increases in airborne concentrations during handling followed the

order: raw MWCNT > C₆₀ fullerenes > functionalized MWCNT > carbon black (no significant increase above background observed). It was also observed that airborne particle concentrations were inversely related to particle size, with higher number concentrations observed for the smallest measured particle size ranges (*i.e.*, < 1 μm). TEM images showed that airborne C₆₀ fullerenes, carbon black, and functionalized MWCNT released during the handling process were present as agglomerates rather than individual primary particles.

- Increases in airborne particle number concentrations resulting from the sonication process followed the order: carbon black > functionalized MWCNT > raw MWCNT > C₆₀ fullerenes. Like with the handling processes, number concentrations were highest for the smaller sized particles. Despite evidence of substantial agglomeration in the liquid suspensions based on TEM images, the highest airborne particle concentrations were measured for sonication of the carbon black suspensions. In comparison, MWCNT and C₆₀ fullerenes were observed to be well-dispersed in aqueous suspensions, with sonication yielding lower airborne concentrations. Aerosol formation was found to be greater for aqueous suspensions containing natural organic matter, which resulted in the release of aerosol water droplets.

Discussion and Implications:

- With increasing production and use inevitable as greater numbers of nanotechnology applications move towards commercialization, workplace exposures to nanomaterials are a pressing concern. Despite being a single pilot study (*i.e.*, a handful of experimental data points with no statistical analysis), Johnson *et al.* report findings suggesting that substantial airborne exposures can potentially arise from two common laboratory processes under certain conditions. The data reaffirms that the handling of dry nanomaterials can result in increased airborne particle releases. It should be noted that the air ventilation systems inside the laboratory hood were turned off during the experiments. If these systems were operational, air currents may have resulted in even greater nanomaterial releases in the hood, such as from an open spatula during handling. However, it is possible that concentrations outside the hood would be diminished by use of the air ventilation system. Second, it was interesting to note that airborne particle number concentrations increased during sonication of aqueous suspension of some nanomaterials, which is contrary to popular belief. However, the effect of natural organic matter on airborne particle emissions during sonication could not be determined conclusively due to an incomplete experimental design.
- Another interesting observation was the differential behavior of hydrophilic (*i.e.*, carbon black and functionalized MWCNT) and hydrophobic (*i.e.*, C₆₀ fullerenes and raw MWCNT) carbon-based nanomaterials. During weighing and handling, higher airborne concentrations were observed for the more hydrophobic C₆₀ fullerenes and raw MWCNT. However, during the

sonication process, airborne concentrations were found to follow a reverse trend, with higher concentrations of the more hydrophilic carbon black and functionalized MWCNT. These results suggest that hydrophilic nanomaterials are released in the aerosol water droplets, with lower airborne concentrations of the more hydrophobic materials since the hydrophobic materials are less likely to be attached to water droplets.

- Currently, no occupational exposure limits are mandated for engineered nanomaterials in laboratory and workplace environments, and safe work practices for handling nanomaterials are still developing. With sonication being a critical process for nanomaterial synthesis and handling, these findings suggest that additional precautions may be required to prevent continued exposures to laboratory workers. Further, additional studies are needed for other types of nanomaterials (*i.e.*, metal oxides and quantum dots) to inform the development of nanomaterial-specific health and safety guidelines.

2. Porter, DW; Hubbs, AF; Mercer, RR; Wu, N; Wolfarth, MG; Sriram, K; Leonard, S; Battelli, L; Schwegler-Berry, D; Friend, S; Andrew, M; Chen, BT; Tsuruoka, S; Endo, M; Castranova, V. 2009. "Mouse Pulmonary Dose- and Time Course-Responses Induced by Exposure to Multi-Walled Carbon Nanotubes." *Toxicology*. Doi: 10.1016/j.tox.2009.10.017.

Abstract: https://www.researchgate.net/publication/38036881_Mouse_pulmonary_dose_and_time_course_responses_induced_by_exposure_to_multi-walled_carbon_nanotubes

Synopsis:

- Multi-walled carbon nanotubes (MWCNTs) consist of as many as 20-50 layers of graphite sheets rolled into a cylinder, with a diameter less than 100 nm, and of varying length. Due to their ability to conduct electricity and heat, coupled with their mechanical strength, MWCNTs have a wide range of both current and potential future applications, including in electronic and medical devices, automotive and aerospace industries, and sporting goods. Currently there is concern regarding occupational exposure to respirable MWCNTs. *In vivo* studies in which animals were exposed via intratracheal instillation indicate MWCNTs can persist in the lung for at least 28 days following exposure, and can cause both inflammation and fibrosis. Inhalation studies indicate MWCNTs can be translocated to the pleural space, and cause subpleural fibrosis. These *in vivo* studies used exposure concentrations and doses much higher than potential workplace exposures, and their relevance to potential health effects in workers has been questioned. The objective of the study by Porter *et al.* was to evaluate ability of MWCNTs to induce pulmonary inflammation, damage and fibrosis, using occupationally relevant exposure levels.
- MWCNTs were obtained from Mitsui & Company. The overall trace metal content of the MWCNTs was 0.78%,

consisting primarily of sodium (0.41%) and iron (0.32%). Despite the presence of iron, the MWCNTs did not generate ROS. Endotoxin levels were below the detection limit. MWCNT suspensions were prepared in dispersion media (DM), intended to simulate bronchoalveolar lavage fluid (BALF), and consisting of a physiological saline solution with added glucose, albumin and lipid. Specific pathogen-free, 7-week old, male C57BL/6J mice were exposed to 0, 10, 20, 40 or 80 μg MWCNT, via pharyngeal aspiration.

- BALF was collected at 1, 7, 28 and 56 days post-exposure, and analyzed for lactate dehydrogenase (LDH) and albumin, to assess lung damage, and for total cell counts and cell differentials, to assess inflammation. Location of MWCNTs, sites of cytotoxicity and inflammation, and fibrosis were assessed using histopathology. Dose-response of the histopathology endpoints was assessed for all exposure groups at 7 and 28 days post-exposure. Reversibility, persistence and progression of histopathology endpoints was assessed for mice exposed to 0, 20 and 80 μg MWCNTs, at 56 days post-exposure. Pulmonary lymphatics, which are involved in removing particles from the lung, were visualized using podoplanin immunofluorescence, which is a lymphatic endothelial marker, and bronchiolar epithelium was visualized using immunofluorescence for e-cadherin, which identifies epithelial intercellular adhesions.
- MWCNTs were widely distributed within the lung, and within one hour of exposure were found engulfed by alveolar cells and incorporated in alveolar walls. At later time points, MWCNTs had migrated to the alveolar interstitium and were found in interstitial cells. MWCNTs were also found within alveolar macrophages, some of which were loaded with MWCNTs. The MWCNTs sometimes protruded from the alveolar macrophages, and in some cases persisted in the macrophages for at least 28 days.
- LDH was significantly increased for all MWCNT exposure groups at 1 day post-exposure. At 7 days post-exposure LDH levels had further increased in mice exposed to 20 and 40 μg MWCNT, but had returned to control levels in mice exposed to 10 μg MWCNT. LDH levels remained elevated in mice exposed to 40 μg MWCNT at 28 and 56 days post-exposure. A similar dose- and time-related trend was observed for albumin, and for polymorphonuclear cells. Most of the inflammatory cells in the lung were macrophages, many of which were either multi-nucleated or anuclear.
- Lung histopathology evaluation revealed granulomatous inflammation and fibrosis at all MWCNT exposure groups, which persisted through at least day 28 post-exposure, and through day 56 post-exposure for mice exposed to 20 and 80 μg MWCNT. Inflammation extended from the centra-acinar region of the lung to the pleural space in about half of the exposed mice, across all dose groups. MWCNTs had penetrated the pleura at 56 days post-exposure in two mice exposed to 80 μg MWCNTs. In addition, the peribronchiolar lymphatics were dilated in all mice exposed to 80 μg MWCNTs, and in one mouse exposed to 20 μg MWCNTs.

Implications:

- The study by Porter *et al.* showed dose- and time-dependent effects on pulmonary inflammation and cytotoxicity, as well as fibrosis, in mice exposed to MWCNTs. The study authors also showed that MWCNTs can persist in the lung, and can also migrate to the pleural space. Based on their morphology, there is concern that MWCNTs could cause pulmonary effects similar to those caused by asbestos. Results from this study indicate that MWCNTs may be able to cause effects similar to asbestos, based on observations of persistent fibrosis, and ability of MWCNTs to migrate to the pleural space. It is still not clear, however, whether MWCNTs would cause asbestos-like effects of the pleural lining (*i.e.*, such as mesothelioma), given that the MWCNTs studied by Porter *et al.* had a very low metal content, and did not generate ROS. Moreover, extrapolation to asbestos (or other fiber types for that matter) is limited by the lack of a positive control.
- According to Porter *et al.*, the doses used in their study are relevant for potential occupational exposures. The study estimated that a worker could be exposed to the equivalent of the 10 μg dose if they inhaled 400 $\mu\text{g}/\text{m}^3$ MWCNTs for one month, 40 $\mu\text{g}/\text{m}^3$ for 9 months, or 4 $\mu\text{g}/\text{m}^3$ for 7.5 years. Yet, there are obvious differences, in terms of dose-rate, between inhalation exposures occurring over weeks – years, vs. an aspirated dose delivered in a single day. Although MWCNTs can persist in the lung, their low metal content and lack of ROS generation suggests that the observed lung damage may be due to an inflammatory response to the MWCNTs, rather than an intrinsic property of the MWCNTs. If this is the case, dose-rates associated with inhalation exposures may be below critical threshold doses where inflammation-associated damage exceeds repair capability.
- Questions regarding the fate and effects of MWCNTs in the pleural space, as well as whether there is a threshold exposure concentration for inflammation-associated damage, should be evaluated using inhalation exposure studies, with sufficiently long exposure durations and observation periods. Until these questions are answered, exposure to MWCNTs in the workplace should be minimized through the use of good workplace practice (*i.e.*, GoodNanoGuide, NIOSH's "Approaches to Safe Nanotechnology").

Guest Contributors

By Michael Ellenbecker, Sc.D., CIH, and Su-Jung (Candace) Tsai, Sc.D.

The Need for a Comprehensive Nanoparticle Monitoring Strategy

The number of companies that are either manufacturing engineered nanoparticles (ENPs) and/or incorporating them into devices is growing rapidly. In addition, research on ENPs is being performed at many university and government research

labs, such as the Center for High-rate Nanomanufacturing (CHN) at the University of Massachusetts Lowell, where we work. All of those companies and labs need to worry about the potential for the exposure of their workers to ENPs and the potential for ENP releases from their facility into the surrounding environment. There is a basic problem, however, since neither OSHA nor EPA has issued any standards relevant to ENPs. Managers are left not knowing what constitutes an “acceptable” worker exposure or environmental release. In fact, there is very little guidance on what exactly should be monitored – airborne mass concentration (total, respirable, $PM_{2.5}$?), particle surface area concentration, particle total number concentration, particle number concentration as a function of size, dermal exposure, etc.

There is evidence that some companies’ response to this challenge has been less than satisfactory. For example, some manufacturers of carbon nanotubes (CNTs), which are composed of carbon and a catalyst, have referenced the carbon black permissible exposure limit (PEL) in their Material Safety Data Sheet. This mass concentration, 5 mg/m^3 , when converted to a number concentration using a typical CNT size, yields a number concentration of about 10^{15} CNTs/m^3 . At the same time, recent research in animals has indicated that some CNTs may cause mesothelioma, when injected into the peritoneum of rodents. Mesothelioma is a fatal cancer that has been associated primarily with asbestos exposure.^{1,2} Thus, as a hypothetical, the asbestos PEL may be more applicable to some CNTs, not the carbon black standard; this value, 10^5 fibers/m^3 , is 10^{10} times lower than the carbon black standard. This is quite a range between two exposure standards that may be applicable to some CNTs, and illustrates the tremendous uncertainty that now exists as to what might constitute an “acceptable” CNT exposure to workers, or for release into the environment.

In face of this uncertainty, what are company and laboratory managers to do? Our response at the CHN, where we manage the health and safety program, is to follow a precautionary approach. We acquired a sophisticated set of instruments, which allows us to carefully monitor airborne particle concentrations over the range of diameters from 5 – 20,000 nm. We also collect samples for analysis by electron microscopy, which allows us to identify particle morphology and chemical composition. We then monitor possible exposures in our laboratories. Since nanometer-sized particles are ubiquitous, we carefully determine the background concentration, and then measure concentrations during laboratory operations. We deem any exposure that is measurably higher than the background to be unacceptable, and institute engineering and administrative controls to reduce the exposure to background levels. In addition, we train all students and staff in good practices to be followed to reduce the potential for exposure; our Best Practices document is available by contacting one of us. We have recently completed a much more comprehensive report for NIOSH on good practices to be followed by research labs working with ENPs; this document should be published shortly by NIOSH.

We recommend that all facilities with the potential for exposure to ENPs follow this approach, until more guidance is available concerning allowable exposures to specific nanoparticles. If exposures are kept to a minimum, we can avoid harm to workers health.

¹ Poland *et al.*, “Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study,” *Nat. Nanotech.* 3:42388 (2008).

² Takagi *et al.*, “Induction of mesothelioma in p53+/- mouse by intraperitoneal application of multi-wall carbon nanotube,” *J. Toxicol. Sci.* 33(1):105-16 (2008).

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Dr. Tsai (candace@turi.org) is a postdoctoral researcher and Manager of Environmental Health and Safety at CHN. They are available for consultation with anyone concerned about possible ENP exposures at their facility. They may be contacted at the email addresses given above for more information.

Coming In the Next Issue

Research in minipigs showing dermal penetration of titanium dioxide in sunscreen is insignificant

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