Medical Consultation:

Medical consultation and evaluation are available to Dartmouth College employees upon request. Contact EHS to discuss potential occupational exposures or to request a consultation with a doctor through the Occupational/Employee Health Program located at Dartmouth-Hitchcock Medical Center (DHMC) or through Alice Peck Day.

In general, medical follow-up is required:

- In the event of a spill or an event that results in an acute chemical exposure.
- When signs or symptoms develop that may be associated with potential exposure(s) to chemicals used in the laboratory.
- When chemical exposure monitoring data reveals an exposure at or above the action level for an OSHA regulated substance.

Services Provided by EHS:

Periodic audits of laboratories are conducted by EHS to ensure compliance with the requirements of the College's Chemical Hygiene Plan. A lab safety checklist for staff and researchers can be found in Appendix B. Training and information are also provided on an on-going basis to promote and increase awareness. Annually, EHS hires a third party to inspect each chemical fume hood to ensure that it is working and being used properly.

Services Provided by Facilities:

- Repair and preventive maintenance of chemical fume hoods and other local exhaust systems.
- Repair of electrical or other physical hazards in your facilities.
- Inspection of fire extinguishers
- Periodic testing of safety showers.

Working With Particularly Hazardous Substances:

These substances include "select" carcinogens, reproductive toxins and chemicals that have a high degree of acute or chronic toxicity. Acute toxicity can be defined with LD^{50} data (the dose which is lethal to 50% of the test population), any substance with a published LD^{50} < 50mg/kg (any route of exposure) should be considered highly toxic. Substance specific information is available in Appendix H and through the EHS Office (646-1762).

The laboratory supervisor is responsible for ensuring that appropriate additional precautions are taken when working with such chemicals.

General Procedures for High Hazard Substances

* Maintain an accurate record of who uses these substances and the amounts used and stored in the laboratory.

* In the event that toxicologically significant quantities of a particularly hazardous substance are used on a routine or frequent basis, contact EHS at 646-1762 to determine if medical surveillance may be warranted.

* Particularly hazardous substances must be kept in a secondary container to help prevent breaks and spills. This secondary container should be opened inside a chemical fume hood.

* A suitable label should be attached to this secondary container to alert others of the chemical contained therein and (if required) the need for special precautions. *For example: Warning -- Cancer Hazard or Highly Toxic.* Such labels are available from EHS.

* Access to the laboratory should be controlled by the use of appropriate signs that warn of the hazards and indicate the precautions or approval needed for entry. Doors must be kept closed at all times.

* Additional containment devices (such as, glove boxes, shielding or protective filters) may be needed to safely handle, store or protect equipment when using these chemicals.

Note: Any chemical that carries a "skin" designation warning must be treated with extreme caution. Follow the guidance found on the EHS calendar regarding *Essential Information on the Selection and Use of Chemically Resistant Gloves in the Laboratory* concerning the use of flexible laminate gloves as a permeation resistant liner.

*In addition to the use of the proper gloves, eye/face protection and other protective apparel or equipment may be needed. Examples could include chemically resistant gowns, aprons, gauntlets or other specialized protective equipment.

* Work surfaces should be protected from contamination through the use of disposable, absorbent, plastic backed paper. Replace contaminated paper as necessary and handle as hazardous waste.

* On completion of work and before leaving the laboratory, remove all protective apparel and thoroughly wash hands and forearms.

Regulated Carcinogens

Work with the following carcinogens on high volume and regular basis requires additional care and may include exposure monitoring and medical screening:

2-acetylaminofluorene
acrylonitrile
4-aminodiphenyl
arsenic
asbestos
benzene
benzidine (and salts)
1,3-butadiene
cadmium
bis-chloromethylether
1,2-dibromo-3-chloropropane
3,3'-dichlorobenzidine
4-dimethylaminoazobenzene
ethyleneimine
ethylene dibromide
ethylene oxide
formaldehyde/formalin
lead
methylchloromethylether
methylenebischloroaniline
methylenedianiline
α and β-napthylamine
4-nitrobiphenyl
N-nitrosodimethylamine
β-propiolactone
vinyl chloride

Formaldehyde use in the Lab

The use of formaldehyde in the lab may be subject to the Occupational Safety and Health Administration's (OSHA) Formaldehyde Standard (29 CFR 1910.1048) as well as the OSHA laboratory standard. See Appendix H for an OSHA fact sheet on formaldehyde. These procedures apply to all occupational exposures to formaldehyde.

Background

Formaldehyde is a pungent low molecular weight gas that is easily soluble in water. What we typically think of as formaldehyde is actually a 37% (by weight) solution with methanol added to inhibit polymerization. It is combustible when exposed to heat or flame and can react vigorously with oxidizing materials. Polymerized formaldehyde is known as paraformaldehyde, which when in solution can yield free formaldehyde.

Formaldehyde is a human carcinogen and may cause nasal cancer, lung cancer, and possibly brain cancer and leukemia. Workers who are exposed to airborne concentrations of formaldehyde in excess of 0.1 parts per million may experience irritation of the eyes, nose, and throat, as well as coughing, wheezing, chest pains and bronchitis.

OSHA requires that a range of services and controls be established to limit exposure to formaldehyde.

Safe Work Practices

- Formaldehyde must be used with containment ventilation and certified chemical fume hood should be the first choice. Down draft or perfusion tables can also be effective but may require modified work practices and are generally less effective than containment hoods.
- Chemically resistant gloves must be worn. Heavy-duty nitrile or neoprene is best. Disposable NDEX® gloves may be worn when there is a limited splash hazard but must be changed routinely and whenever they become contaminated. Latex gloves are not acceptable.
- Eye protection must be worn. At a minimum, safety glasses for volumes of 500 ml or less. Splash goggles are required for greater amounts.
- If formaldehyde is used routinely, in large quantity or for perfusions, contact EHS to arrange exposure monitoring. Assuming good laboratory practice is followed,

potential exposures should be well controlled. Exposure monitoring provides a useful assessment of chemical handling and practice. Please contact EHS.

Written Program

This program *supplements* but does not replace the College's Chemical Hygiene Plan (29 CFR 1910.1450). All elements of the Chemical Hygiene Plan (CHP) apply to the use of formaldehyde.

Material Safety Data Sheets (MSDS) for hazardous chemicals including formaldehyde are available on the EHS Web Site.

Formaldehyde Container Labeling

All manufacturer container labels for formaldehyde and products that contain formaldehyde must remain affixed and legible. Stock solutions of formaldehyde if not in the original container must be labeled as required by the CHP and must also include the following label:

"**Formaldehyde: Potential Cancer Hazard & Respiratory Sensitizer**"

All boxes or containers of small vials must be labeled as to the preservative used. If the preservative is formaldehyde, it must be labeled as:

"**Formaldehyde: Potential Cancer Hazard & Respiratory Sensitizer**"

These labels are available from EHS.

Concerns over exposure, potential health effects and safe work practices should be discussed with EHS. Through the EHS Exposure Consultation Program, individuals can receive medical evaluation if they have health concerns. A copy of the OSHA Formaldehyde Standard will be provided to the examining health care professional.

No one is to purchase, use or otherwise have available a respirator without permission and training from EHS. Dust or facemasks will provide little or no protection from formaldehyde exposure. Contact EHS if you have any questions.

Formaldehyde Waste Disposal

- Formaldehyde or paraformaldehyde solutions that are less than 1% may be drain disposed with copious amounts of water.

- Formaldehyde or paraformaldehyde solutions that are 1% and greater must be disposed to EHS as hazardous waste. **Dilution as a means of disposal is not acceptable.**

OSHA® FactSheet

Formaldehyde

Formaldehyde is a colorless, strong-smelling gas often found in aqueous (water-based) solutions. Commonly used as a preservative in medical laboratories and mortuaries, formaldehyde is also found in many products such as chemicals, particle board, household products, glues, permanent press fabrics, paper product coatings, fiberboard, and plywood. It is also widely used as an industrial fungicide, germicide and disinfectant.

Although the term formaldehyde describes various mixtures of formaldehyde, water, and alcohol, the term "formalin" is used to describe a saturated solution of formaldehyde dissolved in water, typically with another agent, most commonly methanol, added to stabilize the solution. Formalin is typically 37% formaldehyde by weight (40% by volume) and 6-13% methanol by volume in water. The formaldehyde component provides the disinfectant effects of formalin.

What Employers Should Know

The OSHA Formaldehyde standard (29 CFR 1910.1048) and equivalent regulations in states with OSHA-approved state plans protects workers exposed to formaldehyde and apply to all occupational exposures to formaldehyde from formaldehyde gas, its solutions, and materials that release formaldehyde.

- The permissible exposure limit (PEL) for formaldehyde in the workplace is 0.75 parts formaldehyde per million parts of air (0.75 ppm) measured as an 8-hour time-weighted average (TWA).
- The standard includes a second PEL in the form of a short-term exposure limit (STEL) of 2 ppm which is the maximum exposure allowed during a 15-minute period.
- The action level – which is the standard's trigger for increased industrial hygiene monitoring and initiation of worker medical surveillance – is 0.5 ppm when calculated as an 8-hour TWA.

Harmful Effects on Workers

Formaldehyde is a sensitizing agent that can cause an immune system response upon initial exposure. It is also a cancer hazard. Acute exposure is highly irritating to the eyes, nose, and throat and can make anyone exposed cough and wheeze. Subsequent exposure may cause severe allergic reactions of the skin, eyes and respiratory tract. Ingestion of formaldehyde can be fatal, and long-term exposure to low levels in the air or on the skin can cause asthma-like respiratory problems and skin irritation such as dermatitis and itching. Concentrations of 100 ppm are immediately dangerous to life and health (IDLH).

Note: The National Institute for Occupational Safety and Health (NIOSH) considers 20 ppm of formaldehyde to be IDLH.

Routes of Exposure

Workers can inhale formaldehyde as a gas or vapor or absorb it through the skin as a liquid. They can be exposed during the treatment of textiles and the production of resins. In addition to healthcare professionals and medical lab technicians, groups at potentially high risk include mortuary workers as well as teachers and students who handle biological specimens preserved with formaldehyde or formalin.

How Employers Can Protect Workers

Airborne concentrations of formaldehyde above 0.1 ppm can cause irritation of the respiratory tract. The severity of irritation intensifies as concentrations increase.

Provisions of the OSHA standard require employers to do the following:

- Identify all workers who may be exposed to formaldehyde at or above the action level or STEL through initial monitoring and determine their exposure.

- Reassign workers who suffer significant adverse effects from formaldehyde exposure to jobs with significantly less or no exposure until their condition improves. Reassignment may continue for up to 6 months until the worker is determined to be able to return to the original job or to be unable to return to work – whichever comes first.
- Implement feasible engineering and work practice controls to reduce and maintain worker exposure to formaldehyde at or below the 8-hour TWA and the STEL. If these controls cannot reduce exposure to or below the PELs, employers must provide workers with respirators.
- Label all mixtures or solutions composed of greater than 0.1 percent formaldehyde and materials capable of releasing formaldehyde into the air at concentrations reaching or exceeding 0.1 ppm. For all materials capable of releasing formaldehyde at levels above 0.5 ppm during normal use, the label must contain the words "potential cancer hazard."
- Train all workers exposed to formaldehyde concentrations of 0.1 ppm or greater at the time of initial job assignment and whenever a new exposure to formaldehyde is introduced into the work area. Repeat training annually.
- Select, provide and maintain appropriate personal protective equipment (PPE). Ensure that workers use PPE such as impervious clothing, gloves, aprons, and chemical splash goggles to prevent skin and eye contact with formaldehyde.
- Provide showers and eyewash stations if splashing is likely.
- Provide medical surveillance for all workers exposed to formaldehyde at concentrations at or above the action level or exceeding the STEL, for those who develop signs and symptoms of overexposure, and for all workers exposed to formaldehyde in emergencies.

Recordkeeping Requirements

Employers are required to do the following regarding worker exposure records:

- Retain exposure records for 30 years.
- Retain medical records for 30 years after employment ends.
- Allow access to medical and exposure records to current and former workers or their designated representatives upon request.

Additional Information

For more information on this, and other health-related issues affecting workers, visit OSHA's web site at www.osha.gov.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory-impaired individuals upon request. The voice phone is (202) 693-1999; the teletypewriter (TTY) number is (877) 889-5627.

For assistance, contact us. We can help. It's confidential.

OSHA® **Occupational Safety and Health Administration**
www.osha.gov 1-800-321-6742

DSG 4/2011

Protocols for Acute Toxins and Potentially Unstable Materials

Prior review is warranted when working with certain hazardous chemicals/procedures and where there is a significant risk of harm as follows:

* The chemical(s) to be used can cause severe acute or lethal effects upon exposure by any route of entry to quantities of 5 mg/kg or less based on available LD_{50} data.

Note: Chemicals of unknown toxicity but having characteristics that can be reasonably anticipated to make them dangerous should be discussed with EHS.

* Highly unstable compounds or chemicals that, if combined with other compounds in the procedure, will explode or become uncontrollable.

* Compounds are used that may undergo chemical or physical changes during routine use, and generate by-products that may overcome standard control measures or penetrate available personal protective equipment to cause severe acute or lethal injuries.

* Specific chemicals and operations are used that have been determined by EHS to require approval above the level of the laboratory supervisor.

When one or more of the aforementioned criteria is met, the project principal investigator must ensure that:

1. A specific written safety protocol is developed and submitted to the Dartmouth College EHS for review **prior to ordering the chemical or beginning work**. See the sample protocol included in Appendix E of the CHP. The safety protocol should include: (1) a thorough description of the chemical(s) used--including the potential physical and health effects, (2) a step-by-step review of the work to be performed, (3) a list of the required engineering controls and personal protective equipment, (4) where the chemical(s) are to be kept and proper labeling, (5) a description of inventory control and security provisions, (6) provisions for proper waste disposal and (7) decontamination procedures.

2. Evidence of employee training on the safety protocol is available (see Appendix E for a sample sign in sheet). This information must include a review of the safety protocol developed above, expected behaviors in the event of an emergency, the date that training was provided and the name(s) of those trained. Assistance in laboratory safety training is available from EHS.

3. The proposed activities are conducted by specifically trained personnel in accordance with the approved protocol.

Standard Operating Procedure for Handling Pyrophoric Materials

Minimum Protective Clothing:

- Fire resistant or "FR" lab coat (look for "FR" on label)
- Long pants with closed toe shoes
- Safety glasses or chemical splash goggles
- Two pair 4 mil nitrile gloves (single use disposable give the best dexterity)
- Face Shield is optional
- Nomex/Leather flight gloves are optional but recommended

Minimum Protective Equipment:

- Functioning chemical fume hood
- Access to a working eyewash and safety shower
- Access to a fire extinguisher
- Portable lexan shield (optional as space allows)

Training and Work Practices

- A principle investigator must authorize trained personnel to work with reactive chemicals.
- Training must include observation and direct supervision of work to gain experience with specialized equipment and chemicals.
- Minimum training prerequisites available via the EHS website (www.dartmouth.edu/~ehs): view "Handling Pyrophoric Materials" video, hands on fire extinguisher training, general lab safety program, hazardous waste management web module.
- Never work alone, a co-worker must be present in the lab during liquid transfer
- Work in fume hood at all times, keep the sash as low as possible, remove all un-needed chemical containers, waste bottles and combustibles (paper etc.)
- Use a portable lexan shield as space allows.
- Work in dry/inert glove box can provide superior protection but additional training and instruction specific to glove box operation is required. No lab coat is required when working in a glove box. An FR lab coat is required when the air lock is opened to transfer hazardous chemicals.

Emergency Procedures

- Spills or releases of small amounts of pyrophoric materials may self extinguish in the container or hood bench. If this happens, secure all reaction containers and stop work. Report all spills/fires to EHS and your PI, consult with PI to identify causes/solutions.
- Larger spills and/or fires must be treated as an emergency. If possible close the hood sash, step away from the fume hood and send co-worker to pull the fire alarm. Only fight a fire if the fire alarm has been activated and you have been trained in hands on fire extinguisher use and have your exit path clear.

Technical Notes:

- Transfers of small volumes (1-25 ml) can be performed with glass Luer-lock syringe using dry nitrogen/argon and mineral oil bubbler. Never use plastic syringes for handling pyrophorics.
- Transfers of larger volumes (>50ml) must be performed using a cannula with a Schlenk line or similar nitrogen/argon purged apparatus with mineral oil bubbler.
- Check the MSDS/SDS for each pyrophoric to find compatible cooling solvents. In a spill/release acetone and 2-propanol will react violently with certain pyrophoric liquids (i.e. organolithiums). Consider hexane or heptane as alternatives.
- Ensure all systems, glassware, reaction/transfer/sample containers are dried and cooled to room temperature before use.
- Dry and pure Nitrogen or Argon should have no more than 5ppm moisture or oxygen content.
- Argon must be used where lithium metal is a reactant to prevent the formation of lithium nitride.
- Pyrophoricity will vary between chemicals and also based on concentration, age and environmental conditions. Evaporation of carrier solvent can CONCENTRATE pyrophoric solutions and increase the hazard. Always titrate your pyrophoric to determine the concentration before use.
- Reactions with pyrophoric liquids are exothermic, always use larger than normal reaction vessels and provide pressure release on inert systems.

Definitions/Notes:

Pyrophoric chemicals are liquids or solids that can ignite spontaneously in air. This includes n-butyl lithium, t-butyl lithium sec-butylithium, methyllithium, dibutylmagnesium and some phosphines and silanes. Pyrophoric materials can ignite in air via reactions with moisture (i.e. organolithiums) or oxygen (i.e. phosphines). Carrier solvents with low flash points will increase the hazard. Lower concentrations of pyrophoric material in solvent may be classified as less hazardous" spontaneously combustible" or "water reactive" materials. Dispersions of water reactive solids in solvents (sodium hydride, borohydrides etc.) and some solid chemicals can exhibit pyrophoric characteristics under humid conditions. "Air reactive" materials may decompose, generate toxic/flammable gases and subsequently ignite. "Water reactive" chemicals may react with liquid water to generate toxic/flammable gasses and heat causing a subsequent fire. "Moisture sensitive" materials are generally least reactive, and may simply decompose or lose desired activity if exposed to moisture.

References:

Sigma Aldrich technical bulletins AL-134 and AL-164
FMClithium "Organometallics and reactive specialty organics safe handling guide"
FMClithum "Butyllithium safe handling guide"

Solvent Purification and Distillation

Dartmouth College has adopted a policy of purifying all solvents through solvent purification columns that do not use heat or drying agents (i.e. potassium or sodium). This avoids the high-risk thermal solvent distillation procedures that may lead to fires, explosion or personnel exposures. Solvent purification columns have proven their ability to provide dry and pure solvent and are now considered state of the art (see Cournoyer, et.al., ACS Journal of Chemical Health and Safety July/August 2003).

The steps outlined below addresses basic procedures for set up and operation of solvent purification columns at Dartmouth College.

COMMON HAZARDOUS CHEMICALS PURIFIED ON SITE:

FLAMMABLE LIQUIDS: Tetrahydrofuran (THF), Diethyl ether, Toluene, Dimethylformamide (DMF), Benzene, Ethyl Acetate and Hexanes.

TOXIC LIQUIDS: Methylene Chloride (MeCl, dichloromethane or DCM))

PERSONAL PROTECTIVE EQUIPMENT

EYE PROTECTION: Chemical Splash Goggles, Face Shield if desired.
PROTECTIVE CLOTHING: Flame resistant lab coat, closed toe shoes, nitrile gloves (5 mil thick single use or 16 mil thickness optional),

ENGINEERING / VENTILATION CONTROL

The solvent purification system must be installed with a rated FM/UL flammable liquid storage cabinet or inside a functioning chemical fume hood.

Ensure that all heat generating equipment has over temperature shut off controls installed.

Ensure a reliable supply of low-pressure (<20 PSI) dry inert gas (i.e. nitrogen or argon) to eliminate the chance of ignition in the systems.

SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Follow all manufacturer/provider guidance on installation and use.

If using glassware inspect for defects before use.

Benzene and methylene chloride are confirmed human carcinogens - avoid inhalation and skin contact. Handle should be handled inside the fume hood. Methylene chloride can pass through nitrile gloves (polyvinyl alcohol rubber is best) and there is no approved respirator for this solvent.

Ensure all storage containers are labeled with the name and any hazard warning (i.e. flammable, toxic). Store the flammables in FM/UL rated flammable storage cabinets before they are transferred into the distillation flask.

The ethers (glyme, THF, ether, dioxane) can form explosive peroxides when exposed to air and stored for a time. They must be tested if over one year old. Contact EHS for assistance.

Use secondary containment carriers whenever transporting hazardous material outside of the lab. Use due care and caution when moving hazardous materials.

SPILL AND ACCIDENT PROCEDURES

EHS provides spill kits for small spills that pose no threat to you or others in the area.

For large spills - isolate the spill if possible, evacuate area, keep people away, and Call for help:

Call 911 in the case of fire or flammable solvent spills outside of ventilation
EH&S (8 AM - 5 PM) – 603-646-1762
After Hours call 911 or Safety and Security

WASTE DISPOSAL

Solvent or silica gel used in these systems is regulated as hazardous waste when disposed. Label and contain wastes properly and contact EHS to request waste pick up.

EXEMPTIONS

Exemptions to this policy may be approved on a case-by-case basis. Requests must be in writing, include specific procedures and approval is be signed by the PI, department chair/dean and EHS.

References:
Cournoyer, M.E., Dare, J.H., *The use of alternative solvent purification techniques*, Americal Chemical Society, Journal of Chemical Health and Safety, July/August 2003

Grubbs, R.H. et. Al, *Safe and convenient procedure for solvent purification*, Oranometallics, 1996, 15, 1518

Nanoparticles in the Laboratory

Nanoparticles are defined those particles with at least one dimension of 100 nanometers (nm) or smaller. Engineered nanoparticles are seeing increase use in consumer products and in the lab. Consumer products contain bound up or incorporated nanoparticles, which are not likely to become airborne in free form. Manufacturing and research materials are more varied in form – these procedures apply only to nanoparticles in the free unbound state.

While health hazards of nanoparticles are not fully understood; current evidence is that nanoparticles do enter the body via inhalation and skin contact. Because of their size and relative surface area to mass ratio increase reactivity is assumed. Results from human and animal studies show inhaled nanoparticles can deposit in the respiratory tract and enter the bloodstream. Nanoparticles pose the greatest risk when they are in the form of individual particles, or particles from nanostructured materials that become airborne or come into contact with the skin.

Exposure Limits

There are currently no published exposure limits for nanoparticles from US regulatory or consensus standard groups. There are a number of proposed standards and industry standards of note:

5 ug/m3	carbon nanotube – Bayer “baytubes” 2010
2.5 ug/m3	carbon nanotube – Nanocyl 2009
1 ug/m3	carbon nanofibers – NIOSH current intelligence bulletin 2013
300 ug/m3	titanium oxide – NIOSH current intelligence bulletin 2013

These limits represent the best intelligence currently and in the case of carbon nanotubes are the lowest levels currently detectable with available sampling tools.

ALARA for nanoparticles

The advised approach to exposures to nanoparticles to maintain exposures as low as reasonably achievable through containment ventilation and protective equipment.

Key points:

- HEPA filtration is effective for capture of nanoparticles in ventilation and respiratory protection
- Chemical fume hoods are effective at containment of nanoparticles. Some type of containment ventilation must be used to control exposure and environmental contamination.
- N95 respirators will provide effective filtration of nanoparticles limited by fit and overall hygiene. N99 or N100 respirators offer significant improvements in capture.

Operations of concern:

The National Institute of Occupational Safety and Health (NIOSH) identified the following tasks that may increase the risk of exposure to nanoparticles:

- Working with nanoparticles in liquid media without adequate protection (e.g., gloves)
- Working with nanoparticles in liquid media during pouring or mixing operations, or where a high degree of agitation is involved, will lead to an increased likelihood of inhalation and respirable droplets being formed.
- Generating nanoparticles in the gas phase in non-enclosed systems will increase the chances of aerosol release to the workplace.
- Handling nanoparticle based powders will lead to the possibility of aerosolization.
- Maintenance on equipment and processes used to produce or generate nanoparticles will pose a potential exposure risk to workers performing these tasks (i.e. vacuum chamber cleanout).
- Cleaning of dust collection systems used to capture nanoparticles will pose a potential for both skin and inhalation exposure (i.e. HEPA filter changeout).

Work Procedures

The same procedures, equipment and work-practices used for handling toxic chemicals apply to nanoparticle work. At Dartmouth College the following engineering, work practice and ventilation controls are required when handling nanoparticles in the pure form, in solution or when exposure risks exist:

- Restrict the handling of nanoparticles to areas well within the lab. Labs that handle nanoparticles must have non-recirculating ventilation systems (100% exhaust air). Lab pressurization must be negative to the hallway.
- Food and drink are restricted in all nanoparticle handling areas.
- Hand washing facilities must be provided in all labs. Hand washing must be performed after handling nano materials.
- Handle dry nanomaterials in a fume hood, glove box or a vented HEPA filtered enclosure. Do not work on the open bench with dry nanoparticles.
- Transport dry nanoparticles in closed containers.
- Aerosol producing activities (such as sonication, vortexing and centrifuging) may not be conducted on the open bench. Perform these activities in a fume hood, biological safety cabinet, glove box or a vented filtered enclosure.
- Clean bench tops using soap and water after each work activity.
- Spills of dry nanoparticles must be cleaned with a HEPA vacuum. Dry sweeping is prohibited. Large spills must be reported to EHS.
- Exhaust from all furnaces used to produce nanoparticles must be trapped and connected to a local exhaust source.

Protective Equipment

- Lab coats must be worn when handling nanomaterials in addition to closed toe shoes and long pants.
- ANSI approved safety glasses are required when working in any lab with hazardous materials. Splash goggles are required when liquid splash hazards exist (i.e. pouring, mixing).
- Gloves (disposable nitrile) must be worn when handling nano materials.
- Local exhaust snorkels or ventilated enclosures should be considered before respirators. All respirator use must be coordinated through EHS per our Respiratory Protection Program.

Nanoparticle Waste Disposal

All solutions and solid materials/contaminated debris must be disposed of as hazardous waste via EHS.

References:

National Institute for Occupational Safety and Health – *Nanomaterial Production and Downstream Handling Processes,* November 2013

NIOSH CIB - http://www.cdc.gov/niosh/docs/2013-145/

CDC/NIOSH Nanotechnology page
http://www.cdc.gov/niosh/topics/nanotech/

Select Agent Toxin and Biological Toxin Work

Some toxins are subject to additional controls through the CDC and Department of Agriculture. These laws and policies are intended to: (1) safeguard the use, disposal, transport and storage of these agents, (2) collect and provide information on the location and movement of select agents, and (3) establish a procedure to alert authorities if unauthorized access to these agents occurs or is attempted.

At Dartmouth College, all Select Agent (including work with exempt quantities of toxins) work must be authorized by the Institutional Biosafety Committee (IBC). All requests to obtain, use and dispose of Select Agents must go through the Director of Environmental Health and Safety (EHS) who serves as the Responsible Facility Official (RFO) and is coordinated through the Biosafety Officer in EHS.

What Are Select Agents and who regulates them?

The select agent list and relevant regulatory program information are maintained by the CDC and can be found on the select agent web site http://www.selectagents.gov/. The regulations covering select agents include Code of Federal Regulations, *Title 7, Part 331 (agriculture), Title 9, Part 121 (animals and animal products), Title 42, Part 73 (public health).*

Permissible toxin amounts:

The following toxins are exempt from the full scope of the Select Agent rules provided they are under the control of a principal investigator, treating physician or veterinarian and the aggregate amount does not, at any time, exceed the following amounts:

Abrin 100 mg
Botulinum neurotoxins 0.5 mg
Conotoxin 100 mg
Diacetoxyscirpenol (DAS) 1000 mg
Ricin 100 mg
Saxitoxin 100 mg
Staphylococcal enterotoxins (A, B, C, D and E subtypes) 5.0 mg
T-2 toxin 1000 mg
Tetrodotoxin 100 mg

Use of these toxins requires and number of steps for compliance including

- Receive IBC approval before possession
- Inventory tracking and security, log each use, keep toxin locked and secure
- Document destruction or depletion, disposal must be approved and witnessed
- Develop specific procedures, train staff and document your work
- Report all exposures, spills or theft/suspicious activity

There are a number of other toxins of biological origin which exhibit similar toxicity and risk (i.e. – Bungarotoxin, Digitoxin, Pertussis Toxin, Cholera Toxin, Diptheria Toxin), but are NOT on the select agent list (see Appendix G for a more comprehensive list of biological toxins). These toxins should be handled with similar precautions as outlined in this policy (security, inventory control, training, documented disposal etc.)

Controlled Substances:

The Federal Drug Enforcement Administration (DEA) requires that research personnel must have their own DEA license. At Dartmouth, the principal investigator is the responsible individual. Special inventory, security and recordkeeping requirements apply For more information on obtaining a DEA license, contact EHS (646-1762).

TSCA – the Toxic Substances Control Act

TSCA, or the Toxic Substances Control Act (1976), regulates new and existing chemicals for potential environmental and public health effects prior to production or transportation.