OHS Registration #: _____

Expiration Date: _____

STANDARD OPERATING PROCEDURE FOR THE USE AND SYNTHESIS OF ENGINEERED NANOMATERIALS

Any material which has structured components with at least one dimension less than 100 nanometers. Excludes viruses and bacteria.

Instructions: Please complete this form as required by Chapter 12 of the University Chemical Hygiene Plan and University Policy 7-37.

Not all nanomaterials are subject to the approval requirement of the Chemical Hygiene Plan. OHS will advise researchers if they will be required to seek approval from the Chemical Hygiene Committee for the purchase, synthesis and use of this material.

Submit a separate form for each nanomaterial used or synthesized. Copies of the current guidelines and Chemical Hygiene Plan are available at the DOHS web site: http://www.udel.edu/OHS/. For questions, please contact the University Chemical Hygiene Officer at 831-2103.

Please attach a detailed synopsis of how this material will be used in your research.

Section I – Information

1. Principal Investigator(s): _____
2. E-Mail Address: _____
3. Department: _____
4. Address: _____
5. Phone Number: _____ 6. Fax Number: _____
7. Lab(s) to be Used: _____
8. Chemical: Engineered Nanomaterials (Any material which has structured components with at least one dimension less than 100 nanometer), including carbon nanotubes, carbon nanofibers and any other materials of different elemental composition that meet the definition. Please specify the exact nanomaterial used.

PLEASE READ THIS STATEMENT:

From the American Chemical Society (http://membership.acs.org/c/ccs/nano.htm):

The emerging field of nanotechnology has created an intense interest in the health risks associated with working with matter on an ultra-small scale. One nanometer is one-billionth of a meter. These materials present new challenges in understanding, predicting, and managing potential health risks. Exposure to these materials during manufacturing and use may occur through inhalation, dermal contact, and ingestion. Studies have indicated that low-solubility ultrafine particles are more toxic than larger particles on a mass for mass basis. Because of their tiny size, they can get deep into the lungs and, once in the bloodstream, may be able to cross the blood-brain barrier. Other hazards to consider are catalytic effects and fire or explosion. Because of the limited information on the risks of handling these materials, workers should implement stringent controls on exposure when working with them. Until

more knowledge becomes available, CCS is, for now, providing the following guidelines and references for more information.

Other References:

- National Institute of Occupational Safety and Health's Approaches to Safe Nanotechnology http://www.cdc.gov/niosh/topics/nanotech/safenano/
- National Nanotechnology Initiative: http://www.nano.gov/
- Environmental Protection Agency Perspective on Nanotechnology: http://es.epa.gov/ncer/nano/index.html

The following procedures are based in part on information from the American Chemical Society, National Institute of Occupational Safety and Health and basic prudent practices. All toxicological data, albeit limited, indicate that nanomaterials, carbon nanotubes and nanofibers used in research are hazardous and act as carcinogenic materials. Some, based on mechanism and application, can be considered flammable and reactive.

Some materials have increased toxicological effects in the nano size. These materials may move into the blood stream through the skin, cross through the alveoli, or by the stomach and intestines. From the blood stream, nanomaterials can cross into cells, tissues or other organs such as the brain. Do not assume that a material that is non-hazardous in traditional applications and size will also be non-hazardous as a nanomaterial.

Researchers must evaluate the specific nanomaterial used in the research project, experiment or protocol. Additional precautions may be necessary.

This SOP will be updated as more information and research into health effects and specifics hazards of nanomaterials are published. In the mean time, researchers must handle these materials as if they are hazardous.

Material Safety Data Sheets may not be available.

Section II – Use and Storage

A. Purchasing

All purchases of this material must have approval from the Principal Investigator (PI) or authorized personnel before ordering. The user is responsible to ensure that a current Material Safety Data Sheet (MSDS) is obtained unless a current one is already available within the laboratory. Quantities of this material will be limited to _____, and/or the smallest amount necessary to complete the experiment.

B. Authorized personnel

Please select the general categories of personnel who could obtain approval to use this material:

1. ☐ Principal Investigator 2. ☐ Graduate Students 3. ☐ Undergraduates
4. ☐ Technical Staff 5. ☐ Post Doctoral Employees
6. ☐ Other (Describe): _____

Please list the specific personnel and their approval level (Attach an addendum to this form for additional personnel):

NOTE: The Principal Investigator must be aware of all purchases of this material. The Principal Investigator must assure that there is not an exceedance of the quantity limits.

1. _____	☐ Purchase	☐ Use the Material
2. _____	☐ Purchase	☐ Use the Material
3. _____	☐ Purchase	☐ Use the Material
4. _____	☐ Purchase	☐ Use the Material
5. _____	☐ Purchase	☐ Use the Material

The Principal Investigator will update this section when any personnel changes occur. If changes occur, document the changes (include the record of training of additional personnel) in the laboratory's files and submit an addendum to the University Chemical Hygiene Officer with all training documentation.

C. Storage

Materials will be stored according to compatibility and label recommendations in a designated area.

1. Please list compounds that this chemical is incompatible with: Dependent upon the specific nanomaterial used.

2. Please list special storage requirements (I.E.: Refrigerated, Inert Atmosphere, Desiccated, etc.): _____

3. Please list specific storage area (This Area Must be Marked and Labeled): _____

Storage areas will be inspected by laboratory personnel on a regular basis. Personnel will check for safety concerns such as improper storage, leaking/damaged container(s), damaged labels, quantities in excess of approved limits, theft/disappearance of material, etc. The inspector will also determine if an inventory reduction is possible. The Principal Investigator will designate one individual to complete this inspection.

4. Please select an inspection frequency:

☐ Weekly ☐ Biweekly

☐ Bimonthly ☐ Monthly

D. Use location:

Materials shall be used only in the following designated areas.

Check all that apply:

1. ☒ Fume Hood 2. ☒ Glove Box

3. ☒ Other (Describe): HEPA-Filtered Powered-Exhaust Laminar Flow Hood

Section III – Personnel Safety and Protection

A. Training requirements:

All users must demonstrate competency and familiarity regarding the safe handling and use of this material prior to purchase. The Principal Investigator is responsible for maintaining the training records for each user of this material. Training should include the following:

1. Review of current MSDS, if applicable
2. Review of the OSHA Lab Standard
3. Review of the Chemical Hygiene Plan, specifically Chapter 12, Health Hazards
4. Special training provided by the department/supervisor (Right to Know)
5. Review of the departmental safety manual if applicable
6. Safety meetings and seminars
7. One-on-One hands-on training with the Principal Investigator or other knowledgeable laboratory personnel.

B. Personal Protective Equipment:

All personnel are required to wear the following personal protective equipment whenever handling this material:

1. Proper Laboratory Attire (Pants or dresses/shorts below the knees, sleeved shirt, close-toe shoes)
2. Safety Glasses
3. Lab Coat

Personnel may be required to wear other Personal Protective Equipment when working with this material. The Principal Investigator should contact the University Chemical Hygiene Officer to discuss the selection of chemical protective clothing (aprons, suits and gloves) and respirators. Please check all that apply:

1. ☐ Chemical Safety Splash Goggles	2. ☐ Face Shield
3. ☒ Chemical Protective Gloves (Describe): No specific data is available for glove material at this time. Nanomaterials must not be handled with bare hands. Researchers should also avoid handling nanomaterials with gloved hands. Limited evidence has shown that materials less than 27 nanometers can move through standard chemical protective gloves.	
4. ☐ Chemical Protective Clothing (Describe): _____	
5. ☐ Chemical Protective Splash Apron (Describe): _____	
6. ☒ Respirator (Type): As needed, after OHS approval - N, P or R 100	
7. ☐ Other (Describe): _____	

C. Safe Work Practices

The following safe work practices should be employed when using this material:

1. Wear all required personal protective equipment
2. Cover open wounds
3. Wash hands thoroughly when work with the material is completed
4. No mouth pipetting
5. Use of sharps, such as glass Pasteur pipettes, needles, razor blades, etc. should be avoided or minimized
6. Must not work alone in the laboratory
7. Be sure to consider the hazards of precursor materials in evaluating process hazards.
8. Avoid skin contact with nanoparticles or nanoparticle-containing solutions by using appropriate work procedures. As noted above, chemical protective gloves may not protect against exposure to nanomaterials. Do not handle nanoparticles with your bare skin.
9. If it is necessary to handle nanoparticle powders outside of a HEPA-filtered powered-exhaust laminar flow hood, wear appropriate respiratory protection. The appropriate respirator should be selected based on professional consultation with DOHS.
10. Use fume exhaust hoods to expel fumes from tube furnaces or chemical reaction vessels.
11. Dispose of waste nanoparticles according to hazardous chemical waste guidelines.
12. Wet clean up methods should be employed as the primary clean up technique. Vacuum cleaners used to clean up nanoparticles should be tested, HEPA-filtered units. Do not dry sweep or use regular vacuum cleaners.
13. Equipment previously used to manufacture or handle nanoparticles should be evaluated for potential contamination prior to disposal or reuse for another purpose.
14. Lab equipment and exhaust systems should also be evaluated prior to removal, remodeling, or repair.
15. Given the differing synthetic methods and experimental goals, no blanket recommendation can be made regarding aerosol emissions controls. This should be evaluated on a case by case basis.
16. Consideration should be given to the high reactivity of some nanopowders materials with regard to potential fire and explosion hazards.
17. Efforts should be made to always work with these materials in solution, being cognizant of the synergistic effects of some chemicals such as dimethyl sulfoxide. The primary exposure route for nanomaterials is inhalation. Working with the materials in solution minimizes the risk of an inhalation exposure. Materials in solution will still present an absorption hazard. All personal protection equipment must be employed and users should prevent any contact with the solution, regardless of chemical protective clothing. Nanomaterials of certain sizes have been found to easily move through chemical protective gloves.
18. Please list out an additional safe work practices: _____

D. Personnel Decontamination

For most exposures, decontamination should occur as follows:

1. Small Skin Exposures –

    a. Wash contaminated skin in sink with tepid water for 15 minutes
    b. Have buddy locate the MSDS, if applicable
    c. Wash with soap and water
    d. Contact Occupational Health and Safety at 831-8475 for further direction

2. Eye Exposure –

    a. Locate the emergency eye wash
    b. Turn eye wash on and open eyelids with fingers
    c. Rinse eyes for 15 minutes
    d. Have buddy contact 911 for the Newark Campus, 9-911 for all others and locate the MSDS, if applicable
    e. Notify OHS

3. Large Body Area Exposure –

    a. Locate the emergency safety shower
    b. Stand under shower and turn it on
    c. Rinse whole body while removing all contaminated clothing
    d. Have buddy contact 911 for the Newark Campus, 9-911 for all others and locate the MSDS, if applicable
    e. Rinse body for 15 minutes
    f. Notify OHS

Please list any special decontamination procedures: _____

E. Exposure Symptoms and Treatment

Please list the emergency procedures to be followed in the event of an exposure. These will be found in the MSDS for the compounds:

1. Skin/eye contact:

    a. Symptoms: Unknown, limited evidence of cancerous tumor formation at the exposure site and body wide, as the material crosses into the blood steam

    b. First Aid: See Section D

2. Ingestion:

    a. Symptoms: Unknown, limited evidence of cancerous tumor formation at the exposure site and body wide, as the material crosses into the blood steam

    b. First Aid: Contact 911 and obtain a MSDS, if applicable.

3. Inhalation

    a. Symptoms: Unknown, limited evidence of cancerous tumor formation at the exposure site and body wide, as the material crosses into the blood steam

b. First Aid: Leave the contaminated area; utilize the safety shower as directed in Section D. Contact 911 and obtain a MSDS, if applicable

4. Injection

a. Symptoms: Unknown, limited evidence of cancerous tumor formation at the exposure site and body wide, as the material crosses into the blood steam

b. First Aid: Contact 911 and obtain a MSDS, if applicable

The ChemWatch MSDS, which is available at http://www.udel.edu/OHS/ oftentimes, has treatment information for Emergency Room Personnel and Doctors to follow. Please list any information that can be provided to assist with the treatment: _____

F. Spills

The laboratory should be prepared to clean up minor spills (25 ml/25 g or less) of highly toxic/carcinogenic materials should they occur in a properly operating fume hood. Chemical spill clean up guidance can be found at http://www.udel.edu/OHS/chemspillkit/chemspillkit.html. Laboratory personnel cleaning up a spill will wear all personal protective equipment listed above and manage all cleanup debris according the waste disposal section. Notify OHS of any spills, even if the lab staff handled the clean-up.

Please list the following:

1. Location of Spill Cleanup Materials for a small spill: _____

2. Any special measures/cleanup material required to cleanup a spill: Utilize wet methods to clean up dry spills, avoiding the generation of dusts or aerosols. Use a certified HEPA vacuum if wet clean up methods are not possible. Handle spilled material through the hazardous chemical waste program

If a spill is large or occurs outside of a fume hood, the laboratory occupants should immediately vacate the laboratory, close all doors and contact Occupational Health & Safety at 831-8475 during working hours or 911 after hours. If the laboratory personnel determine that the spill is not contained to the lab or could cause harm to people outside the laboratory, they should pull the building fire alarm and go to the Emergency Gathering Point to await the University Police and Emergency Responders. The responsible/knowledgeable person should provide the University Police and the Emergency Responders with the following:

1. Common Name of the Material Involved

2. A copy of a MSDS, if possible or applicable

3. Any pertinent information related to the emergency, such as location in the lab, other hazards in the lab, etc.

G. Emergency Phone Numbers:

Below is a list of emergency numbers to contact in the event of an emergency:

1. Police, Fire or Medical Emergency, call – 911 on the Newark Campus, 9-911 for all others

2. Occupational Health & Safety – X8475

Please provide a list of other emergency phone numbers, such as after hour contacts for laboratory personnel or any other important phone number, to be used in the event of an emergency: _____

H. Other Special precautions

Please list any other special precautions or procedures not listed in the above sections. Please be as specific as possible: _____

Section VI – Waste Disposal

The authorized person using this material is responsible for the safe collection, preparation and proper disposal of waste unless otherwise stated below. Waste shall be disposed of as soon as possible and in accordance with all laboratory and University procedures. All personal must obtain chemical waste disposal training via DOHS.

Specific instructions: Until further evidence is published, researchers must handle waste nanomaterials as a hazardous chemical waste. Label waste containers with a DOHS Orange Chemical Waste Label. Utilize plastic containers, Nalgene LDPE or Justrite containers for liquid waste. Solid contaminated waste must be moistened / wetted and sealed to prevent aerosol and dust generation. Follow all standard chemical waste procedures listed in the Chemical Waste Procedures Manual and the Chemical Hygiene Plan.

Section V – Signature and Verification

Your signature below indicates that you have completed this form accurately to the best of your knowledge, you acknowledge all requirements and restrictions of this form and that you accept responsibility for the safe use of the material.

1. Prepared By: _____ Date: _____

   Signature: _____

2. Principal Investigator: _____ Date: _____

   Signature: _____

Section VI – Approval Process, as applicable

Not all nanomaterials are subject to the approval requirement of the Chemical Hygiene Plan. OHS will advise researchers is they will be required to seek approval from the Chemical Hygiene Committee for the purchase and use of this material.

A. University Chemical Hygiene Officer Approval

The Principal Investigator should have this form completed as accurately as possible. Please e-mail or fax this form to the University Chemical Hygiene Officer at eich@udel.edu or 831-1528. The Chemical Hygiene Officer will review and verify the form and make any necessary changes or updates.

1. University CHO: _____ Date: _____

Signature: _____

B. Conditional Approval to Purchase and Use

This form will then be e-mailed or faxed to a member of the University Chemical Hygiene Committee (CHC), usually from the same department as the requesting PI. The Committee Member will meet with the Principal Investigator or designee and discuss the form and the use of the material. If the Committee Member finds the procedure acceptable, they can offer a conditional approval for purchase and use of this material.

2. CHC Member: _____ Date: _____

Signature: _____

C. Full Approval

A signed copy of the form will be sent, via campus mail, to the University Chemical Hygiene Officer, who will bring it up at the next Chemical Hygiene Committee Meeting for full approval. All approvals will be good for two years. The complete, signed approval form will kept on file with Occupational Health & Safety and a copy will be sent to the Principal Investigator to keep on file.

3. Acceptance: _____ Date: _____

CHC Chair: _____

Signature: _____

D. Approval Expiration

The approval for use and purchase of this material will expire should any of the approved information change, with the exception of Section II, B and C, Authorized Personnel and Storage Location, or two years after CHC approval. If, at the end of two years, the procedure is substantially the same, the Principal Investigator can complete a renewal form and send it to the University CHO, who can approve the renewal for an additional two years.

CHECKLIST FOR POSSESSION AND USE OF CARCINOGENS AND HIGHLY TOXIC MATERIALS

The checklist is provided to assist a researcher with the approval process for possession and use of carcinogens and highly toxic materials. This form may be kept on file in the laboratory with the SOP to serve as documentation. The complete procedure can be found in the University Chemical Hygiene Plan in Chapter 12.

Date and Initial	
_____	1. Complete a Standard Operating Procedure/Approval Form For Carcinogens and Highly Toxic Materials and submit this form to OHS for review
_____	2. Review and make OHS's changes and recommendations
_____	3. Meet with a member of the University Chemical Hygiene Committee to review the approval form and the use of the material.
_____	4. Submit (via campus mail) the completed and signed form back to the University Chemical Hygiene Officer for conditional approval to purchase and use the material. The University Chemical Hygiene Committee will review this form at the next scheduled meeting for full approval.
_____	5. Complete a Job Hazard Analysis (JHA) for each experiment in which this compound is used. These JHAs must be kept on file in the laboratory and updated every 5 years or when a process changes.
_____	6. Provide and document training for every worker who will use the material. Training shall include hands-on instruction as well as review of the JHA, SOP and the University Chemical Hygiene Plan; specifically Chapter 12.
_____	7. Conduct a trial run with OHS present.
_____	8. Have OHS present the first time a process using this material occurs.