VINSE Analytical Safety Plan & Conduct of Operation

VANDERBILT INSTITUTE OF NANOSCALE SCIENCE AND

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1. Introduction

The VINSE Analytical Core Laboratory is a premier user facility providing expertise, instrumentation, and infrastructure for interdisciplinary nanoscience and nanotechnology research. The facility supports a broad range of nanoscale science and technology projects by providing resources coupled with expert staff support. The Laboratory is fully equipped for conducting materials processing and characterization. The laboratory houses a diverse range of state-of-the-art instrumentation for extensive investigation of optical and structural properties of materials. The laboratory is working under the close supervision of the Environmental Health and Safety (EHS) department.

2. Laboratory Policies

2.1 Personal Protective Equipment

Each user is responsible for and required to use and know the types of personal protective equipment (PPE) available.

2.1.1 Lab Coat

Every user is required to wear a lab coat.

2.1.2 Eye Protection

- Safety glasses are required in a lab.
- Face shields with safety glasses underneath or chemical splash goggles are required when transferring or pouring acid or caustic materials, or where a potential splash hazard exists.
- Inspect before each use the eye and face protection equipment you plan to use. If there is any damage, cracks, debris, or scratches do not use it! Notify laboratory personnel immediately concerning defective PPE.

2.1.3 Gloves

- Chemical resistant gloves shall be worn whenever the potential for skin contact with hazardous materials exists.
- Gloves shall be removed before touching other surfaces (door knobs, telephone receivers, faucet handles).
    1. Heat resistant gloves shall be used for handling hot objects.
    2. Low temperature gloves specifically designed for cryogenic use shall be worn when handling materials like dry ice or liquid nitrogen.
- Before each use, gloves are to be inspected for damage and contamination. If there are any signs of damage, cracks, or contamination do not use the gloves and notify laboratory personnel immediately.

2.1.4 Clothing

- No sandals or open-toed or open heeled shoes are to be worn in a lab. Canvas shoes should be avoided.
- The shoe should have a non-skid sole.

- Clothing should be worn that covers the legs to protect from a potential splash or chemical spill.

2.1.5 Additional Personal Protection

A risk assessment is to be conducted to assess work practices regarding the likelihood of injury. If there is a risk then additional safety protective equipment is recommended.

2.2 Safe Work Practices

To ensure laboratory safety, follow safe laboratory practices, including the following:

- Know about the chemicals and hazards associated with the handled materials.
- Know what to do in different emergency situations.
- Know how to read and interpret SDSs.
- Wear personal protective equipment, as appropriate.
- Follow safe practices for working with chemicals. (Refer to Section 3.2 Chemical Hazards for more information.)
- Protect unattended operations from utility failures and other potential problems that could lead to overheating or other hazardous events.
- Avoid producing aerosols.
- Use extreme care when working with needles, blades, and glass.
- Do not eat, drink in the laboratory.
- Clean contaminated equipment and spills immediately. Avoid contaminating equipment with chemicals.
- Avoid using dry ice in enclosed areas. (Dry ice can produce elevated carbon dioxide levels.)

2.2.1 Laboratory Hoods

- Fume hoods are installed in laboratories to protect workers from hazardous vapors. However, simply conducting these experiments in the fume hood does not guarantee adequate protection. The fume hoods must be used properly.
- Reduce obstructions in the fume hood to improve its effectiveness by allowing adequate air flow across the working surface with minimum turbulence.
    - Minimize the number of objects stored in the hood – keep at least 50% of the working surface clear, if possible.
    - Always place containers and equipment at least six inches into the hood from the face.
    - Place containers and equipment toward the sides of the hood to reduce obstruction of the exhaust slots.
    - If possible, elevate equipment and containers two to three inches above the working surface using perforated or slotted shelving to minimize disruption to the airflow.
    - Keep head out of hood.
- Check the airflow indicator prior to use to ensure the fume hood is drawing air. Hoods are equipped with airflow monitors that display a digital readout of the face velocity and or beep or light up when the velocity is too low.

- Keep the sash at 18 inches or less from the working surface while working in the hood to ensure maximum flow rate and to protect yourself from potential chemical splashes or explosions. The sash will be closed automatically when you are not working in the hood.
- Work at least 6 inches into the hood from the face to minimize the potential for fumes to escape.
- **Fume hoods are not the same as biosafety cabinets**.
- Use of cancerous gases, biohazards, radioactive materials is prohibited. Open fire sources are not allowed to be used inside fume hoods.

2.2.2 Refrigerator Safety

- Storage of food or drink in refrigerator is prohibited.
- The refrigerator is not designed for storage of flammable materials.
- Understand the storage requirements for each chemical or sample before placing it in a refrigerator. Refer to the SDS of the chemical for more information.
- Label the materials with the contents, owner, and date of acquisition.
- Follow all chemical compatibility storage guidelines.
- Segregate incompatible materials.
- All materials must be properly capped and sealed. Avoid using foil or parafilm as a primary method for sealing the container.
- Shelves must be compatible with the materials stored and secondary containment should be used when storing hazardous liquids.
- Remember that power outages will cause a rise in temperature within the unit.

2.2.3 Using Sharps

Observe the following safety practices when using sharp devices such as needles, scalpels, Pasteur pipettes, slides and capillary tubes while performing lab procedures to minimize the potential for occupational injuries.

- Eliminate the use of devices sharp enough to puncture your skin (including glass) whenever possible. If you cannot eliminate their use, consider options that have shatter-proof features (i.e., Teflon coating).
- Get trained in proper techniques before using sharp devices in conjunction with hazardous materials.
- Use scalpels blades in the appropriate and safe manner.
- Do not leave sharp devices out in the environment any longer than necessary.
- Minimize “two-handed techniques” with sharps. Recapping needles, or passing sharp devices (i.e., scalpels) from one person to another, are common examples of “two-handed” techniques that can lead to hand injuries with contaminated sharps.
- Do not put excessive force on a sharp’s device. Don’t bend or break sharps.
- Use an appropriate sharps container for disposal of sharps waste.
- If you sustain an injury with a sharp, take appropriate action to minimize lab-acquired infection risk.

2.3 Behavior in the Laboratory

- Laboratory users shall act in a professional manner at all times.
- No horseplay and practical jokes.
- Laboratory users shall be aware of the location and proper operation of laboratory safety and emergency equipment.

2.4 The Buddy Rule

The buddy system is required when working with hazardous materials and for particularly risky operations. The laboratory buddy becomes the first responder in the event of an accident or other laboratory incident.

The buddy system means that two authorized users of the laboratory (those who have VU ID card access to the facility because they have attended the User Orientation and EHs Lab Safety Training) must access the facility in pairs. Any VINSE user who has access to the facility can serve as a buddy, including a member of your research group. During normal business hours this rule may be satisfied if VINSE staff member is present in the Analytical laboratory. After-hours, a second authorized user present in the Analytical Laboratory can be a safety buddy.

2.5 Data Management Policy

- VINSE does not archive data.
- Data collected on VINSE instruments may be temporarily stored on designated hard drives.
- Users are advised to make copies of all data on a per use basis.
- Use the VINSE Anti-Malware Kiosk to scan your storage media**.**

2.6 Day Use Lockers

Day Use Lockers have been provided to minimize personal property that is brought into the laboratory and to avoid a risk of spreading a laboratory contamination outside the lab.

- Lockers are unassigned and are available on a first come first served basis.
- Lockers are intended for day use storage of personal effects (coats and backpacks) during a reservation period and prior to entering VINSE laboratory.
- The provided locks may be applied for security.
- Neither long term nor short term storage of chemicals and biological samples is permitted in VINSE lockers.

3. Laboratory Hazards and Safety

The primary safety considerations in the Analytical laboratory concerns the hazards of the specimens themselves, and the proper use of the analytical instrumentation. **Training and approved procedures for the use of this facility are available from the laboratory staff**.

This manual provides the basic safety rules and guidelines that help ensure that user's work in the Analytical Laboratory is as productive and as safe as possible.

For the most part, rules on chemical use are formulated on the basis of chemical information derived from Safety Data Sheets (SDS), the properties of individual chemicals, and common sense. In addition, a significant number of state and federal regulations cover safe chemical use in the workplace and the proper disposal of hazardous waste materials.

Potential hazards in the Analytical laboratory fall into several categories:

- Chemicals
- Flammable Gases – hydrogen mixture
- Non-toxic gases – nitrogen, argon
- Thermal energy from hot plates
- Tissue damage from cryogenic liquids at very low temperatures
- Electrical energy that can cause shocks or burns
- Pneumatic and Hydraulic energy
- Non-ionizing radiation sources – UV lamps
- Biological materials
- Nanomaterials
- Lasers
- Mechanical energy from moving parts
- Sharp edges

The following general guidelines form the foundation of the Analytical Lab Safety Plan. This plan is not intended to provide stand-alone guidance and is superseded by the Vanderbilt University Chemical Hygiene Plan and in consultation with the office of EHS.

3.1 Risk Assessments

Risk assessments determine the level of hazard or risk associated with any procedure and assess whether current control methods are adequate or need to be improved. They should be performed when:

- It is the first time that a procedure is to be performed.
- There is only limited knowledge about a hazard or the risk or how the risk may result in injury or illness.
- The situation involves a number of different hazards that are part of the same work process and there is a lack of understanding about how hazards may impact on each other to produce new or greater risks.
- There is to be a significant change of procedure practice from the original assessment.

3.2 Chemical Hazards

The procedures, including the dispensing of chemicals, must be performed in designated fume hoods.

- Each chemical must be declared to and reviewed by the Laboratory staff and have SDS on file PRIOR to its introduction to the lab.
- All chemicals and waste must fit in designated ventilated fire-proof storage locations.
- SDS should be reviewed before starting the work.

- Before beginning laboratory research with a particular substance, the hazard properties of that substance should be known in order to determine appropriate personal protection and safe handling procedures.
- Wear gloves and other required PPE when handling or working with any chemical.
- Always avoid skin contact with chemicals.
- Mixing two or more substances may form reaction products that are significantly more toxic than the starting reactants. Always assume that all substances of unknown toxicity are toxic.
- Properly label all containers: Name, *PI*, Date, & Contents.
- Never leave chemicals unattended without identification.
- For reasons of contamination NEVER put any chemicals back into their original containers.
- Pour only the necessary amounts of chemicals you are planning to use.
- Proper chemical disposal is mandatory.
- All liquid and solid wastes must be put in the appropriate labeled container and *secondary storage container* for pickup & disposal.
- When chemicals are hand carried, the primary container (i.e., the bottle) should be placed in a secondary container (i.e., a bottle carrier) to protect from breakage and spillage.

3.2.1 Solvents

All solvent containers are limited to 1 gallon or less. The solvents containers are stored in designated flammable cabinet.

- Vapors from some organic solvents can form an ignitable mixture in air.
- Many flammable liquids or organic solvents are potentially hazardous to researchers by inhalation.
- Skin contact with organic solvents should be avoided, irritation or skin absorption are possible with some flammable chemicals.
- Damage to the eyes from contact with solvents range from irritation to severe chemical corrosion damage.
- Emergency showers and eyewashes shall be used when skin or eye contact occurs. Get first aid attention immediately for any chemical exposure.
- Hotplates are not intrinsically safe to heat flammable liquids.

3.2.2 Acids and Corrosives

A corrosive chemical is a chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.

- Contact with skin, eyes, respiratory or digestive tract causes severe irritation or burns.
- Store all acids and bases in appropriate cabinets.
- Never add water to concentrated mineral acids or bases – add the acid or base to water.

3.2.3 Reactives

A reactive (unstable) chemical is one which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense or will become self-reactive under conditions of shock, elevated pressure or temperature.

- Water sensitive chemicals react violently in the presence of water.

- Pyrophoric materials may ignite in air at or below room temperature in the absence of added heat, shock or friction.
- Store water reactives according to label directions.
- Use only in a hood, glove box.

3.2.4 Chemical Spills

When laboratory spills occur, it is necessary to take prompt and appropriate action.

Appropriate action will depend on the severity of the hazards associated with the chemical spilled.

- If the spill is minor and of known limited danger, begin the cleanup operation immediately.
- If the spill is unknown in chemical composition or potentially dangerous (explosive, toxic fumes), evacuate the room and contact EHS.
    - If it is suspected or known that the spill is extremely dangerous:
    - Call VUPD (at 911 from on-campus phone and 615-421-1911 from non-VU phone) who will alert the Fire Department and EHS.
    - Evacuate the building by pulling the nearest Fire Alarm Pull Station.

3.2.5 Chemical Spill Cleanup

Chemical spills present a variety of hazards in the workspace. For example, corrosives such as acids and caustics can cause severe burns on contact to skin and eyes, and the presence of fumes can be damaging to the respiratory system. Also, many organic solvents are flammable and release vapors which are irritating to the eyes and respiratory system. Taking personal protective measures is always the first step in responding to chemical spills.

Spill Treatment kit contains spill control agents specially formulated to treat particular classes and sizes of chemical spills.

Evaluate agent suitability for spill size and type. Consult SDS for proper cleanup procedure. Do not use any agent on substances other than those listed for that agent. Follow Spill Kit Treatment and EHS Guide to safely clean up the spill.

Spill control begins by spreading an appropriate absorbent material on the spill. Spill cleanup kits are available in the laboratory. Be sure to call EHS for disposal procedure or pickup of spill cleanup materials. If in doubt about the proper spill cleanup procedures, contact EHS.

3.3 Physical Hazards

Physical hazards include compressed gases such as clean dry air, nitrogen and argon, hot surfaces, cryogenic liquids such as liquid nitrogen, sharps such as pipettes and razor blades, lasers, moving parts, noise, and electricity.

3.3.1 Compressed Gases

The pressure inside gas cylinders can be as high as 2500 pounds per square inch gauge (psig). Gas cylinders are stored in designated areas, such as the cylinder storage facility on the ESB loading dock.

Hazards. Used compressed gases are flammable and inert. Because of the significant pressure present in a full gas cylinder, a gas cylinders with a broken valve (e.g. from dropping a cylinder) can become a missile capable of penetrating walls.

Controls. All compressed gas cylinders are handled by VINSE staff.

3.3.2 Liquid Nitrogen

Individuals working with liquid nitrogen should wear eye protection and protective thermal gloves to avoid cryogenic "burns."

The leaks of liquid nitrogen (or any other inert gas) can easily result in the creation of an oxygen deficient environment (which can be immediately dangerous to life and health [IDLH]) for researchers in space which is not well ventilated. Before using liquid nitrogen dewars or cold traps, a thorough process hazard review should be completed on the experimental set up, to assure that a potential IDLH environment has not been created.

3.3.3 Electrical Hazards

In the laboratory, there is the potential for users to be exposed to electrical hazards including electric shock, electrocutions, fires and explosions.

- Do not attempt electrical repairs. All electrical devices must meet state and University construction and grounding requirements.
- Pay particular attention near the plug and where the cord connects to the piece of equipment. If you discover a frayed electrical cord, contact lab staff. Do not use equipment having worn or damaged power cords, plugs, switches, receptacles, or cracked casings.

Common scenarios that may indicate an electrical problem include: flickering lights, warm switches or receptacles, burning odors, sparking sounds when cords are moved, loose connections, frayed, cracked, or broken wires.

3.3.4 Lasers

All laser sources in the Analytical laboratory are contained within the instrumentation and shielded from the users under normal operation. Therefore, no specific laser safety training is required of the users.

Even moderately powered lasers can cause injury to the eye. High power lasers can also burn the skin. Some lasers are so powerful that even the diffuse reflection from a surface can be hazardous to the eye.

The laser energy from excitation lasers may be visible or invisible. Users should never stare directly into the laser beam or its bright reflection. Never tamper with the laser head and safety interlocks**.** Exposure to laser energy or high voltage may result. Exposure to any laser radiation can be dangerous and should be avoided.

Laboratory instruments utilizing lasers:

- Thermo Scientific DXR confocal Raman microscope - Class 3B
- Malvern Panalytical Ultra Zetasizer - Class 3R
- Malvern Panalytical NanoSight NS300 - Class 3B
- Bruker Tensor 27 FTIR spectrometer - Class 2

3.4 Bio-Safety

- The VINSE core laboratories are in compliance with EHS guidelines for the use of biological materials in University laboratories
- All Biological Specimens and Materials are in compliant with the BSL-1 standard
- Research animals are not allowed in VINSE facilities.

Biosafety must be considered whenever experiments involve the use of known or unknown biological agents or cultures, or when an agent has been recently isolated or is suspected to be present in or on any material handled during an experiment.

Biosafety Level 1 represents a basic level of containment that relies on standard microbiological practices with no special primary or secondary barriers recommended, other than a sink for handwashing.

The recommended biosafety level represents those conditions under which the agent can ordinarily be safely handled.

3.4.1 Basic Biosafety Guidelines

- Investigate the origin of all samples and know the potential hazards before you start your experiments.
- Always wear your lab coat, gloves and face protection and consider this the minimum personal protective equipment when working with biological materials.
- Never wear contaminated clothing outside of the lab.
- Always wash your hands -
  - After working around biologically active materials.
  - After removing gloves, lab coat, or other contaminated clothing.
  - Before leaving the lab.
- Do not touch your face while doing work with biologically active materials.
- Always keep lab notebooks and other hard to sanitize materials away from potential contamination.

3.5 Nanomaterials

Nanomaterials are materials having one or more external dimensions, or an internal structure of 100 nm or less, which could exhibit novel characteristics compared to the same material in bulk form.

3.5.1 Special Risks

Unusual physical, chemical, and biological properties are associated with materials at the nanoscale. Many of these properties are useful, but they can also enhance toxicity and increase the potential for negative health effects in the body.

3.5.2 Work Safely

Users engaged in nanotechnology-related research have the potential to be exposed to uniquely engineered materials with novel dimensions, shapes, and physical and chemical properties. Occupational health risks associated with fabricating and using nanomaterials are not yet clearly understood. Minimal information is currently available on dominant exposure routes, potential exposure levels, and material toxicity of nanomaterials.

- Always evaluate the hazards before beginning work with nanomaterials.
- Be aware of chemical and physical hazards risk when working with reactive nanomaterials. Prior to starting work, assess whether large quantities or high concentrations of nanomaterials will be used.
- Handle nanomaterials whenever possible in a form that is not easily made airborne, such as in solution or on a substrate.
- Under certain circumstances, combustible nanomaterials may present a higher risk when exposed to air due to their large surface area and overall small size.
- Carbonaceous and metal dust can burn and explode if an oxidant such as air and an ignition source are present; self-heating may occur when reactive moieties, such as double bonds, are constituents of the carbonaceous material.
- Perform work inside a fume hood.
- Do not exhaust aerosols containing nanomaterials inside laboratory.

When research involves work with engineered particles for which no toxicity data is yet available, it is prudent to assume the nanomaterials may be toxic. Follow the safety guidelines to protect yourself from possible hazards. As with conventional chemicals, research with nanomaterials must be conducted in a manner that is safe and responsible. Elimination or substitution to a less hazardous substance is a basic principle of occupational safety and health. Certain aspects of a process may be changed and result in a less hazardous situation to exist.

3.6 Safety Data Sheets

Safety Data Sheets (SDSs) are maintained for all hazardous chemicals used or stored in the laboratory. The paper copies of SDSs are located in a fire-proof vault located in the Analytical lab. Electronic copies of SDSs are kept on a hard drive of VINSE Anti-Virus Kiosk in the lab and VINSE website.

4. Emergency Procedures

4.1 Life Threatening Emergency

In this case dial 911 from any wired campus phone to summon VUPD, or if calling from your mobile phone, please dial the full 10-digit number for VUPD 615-421-1911.

The Analytical Laboratory user shall be familiar with the location of the fire alarms (pull stations), fire alarm annunciators, fire extinguishers, telephone, emergency numbers, and chemical containment materials.

There is safety shower and eye-wash station in the laboratory. When first using the lab, all researchers should familiarize themselves with this important emergency equipment location.

If a fire alarms sounds, all persons are to leave the laboratory immediately.

4.2 Emergency Reporting Procedures

Call the Vanderbilt University Police Department (at 911 from campus phone and 615-421-1911 from cell phone) for all emergencies. They will dispatch the Police, Fire Department, medical aid, or EHS.

When reporting an emergency, give as much information as possible, such as:

- Location and type of emergency
- Name of victim(s) (if applicable)
- Contact information
- If a chemical is involved, write down the name of the chemical to give this information to emergency personnel.
- If possible, remain at the scene to help explain what happened when emergency responders arrive.

4.3 First Aid Kit

Injuries, which occur in the Laboratory and require medical treatment, should be treated immediately. Laboratory first aid items meeting OSHA and ANSI requirements are designed for use in typical research laboratory necessary to treat injuries that can occur in laboratory environments. For more serious incidents or in any doubt, medical assistance is needed. For non-emergencies during business hours, students should go to Student Health Services and employees should go to the Occupational Health Clinic. For medical emergencies, users should be sent to VUH Emergency Department.

4.4 First Aid Procedures

- CHEMICAL BURNS: Flush the affected area with cold water for at least 15 minutes. Flush eye for at least 15 minutes at an eye wash station or sink.
- THERMAL BURNS: Immerse the burned area in cold water or apply ice until the pain stops. Cover with a sterile dressing.
- POISONS: Call the Poison Center (1-800-382-9097) for assistance in administering poison antidotes.
- BLEEDING: Hold a clean cloth pad directly on the wound and apply hand pressure. Apply a tourniquet only as a last resort.
- FIRES: Put out burning clothing or hair with a fire blanket or water. If these resources are not available, make the victim roll on the ground to put out the flames.