Weighing Hazardous Powders in the Laboratory

The weighing of powders is a routine task in research laboratories. While there are many methods of performing this task the best approach is usually dictated by the hazards associated with the material, its physical properties, and other experimental parameters such as the quantity that is needed and how the powder will be used. Look closely at the interactions you will have with powders and apply the necessary parameters for your protection. In small quantities most powders can be handled easily and safely. This guidance document describes some of the factors that should be considered and describes some specific methods weighing powders.

Hazards of Powders

Before weighing a powder you should understand the hazards associated with it. The manufacturers Safety Data Sheet is a good place to get information though this should not be your only source. Other sources for information include TOXNET or SAX's. In addition to determining the weighing method, the hazard determination will also dictate other things such as ventilation controls, PPE, etc.

Health Hazards

The health hazards of powders may include sensitization, toxicity and carcinogenicity. Sensitization can occur over time due to inhaling small amounts of dust. Even routine exposure to non-toxic powders can lead to respiratory problems. In small quantities most powders can be handled easily and safely however, as the quantity of material you are handling increases so do the chances of an accident happening. A best practice for coping with the hazards associated with powders is to consider the following questions: 1) What is the type and intensity of the hazard associated with this powder? 2) How much will be used or released? 3) What are the chances for exposure? As any of these variables increases so should your control strategies.

Physical Hazards

Powders can also possess a physical hazard. For example, in some situations, metal powders such as aluminum, iron, magnesium and titanium are potentially flammable even in small quantities. When working with flammable powders it is important to keep dust levels at a minimum and use thorough cleaning procedures. Heat, flames, moisture and sparks should be avoided. Depending on the quantity of the substance being used it may be necessary to eliminate all sources of ignition.

Some compounds become shock sensitive when they come in contact with metal surfaces or other materials. Metal azides are such chemicals. These materials are sensitive to friction which can cause an explosion. Picric Acid is sensitive to heat, shock and friction. It reacts with many different materials including metals to form picric salts and with concrete to form calcium picrate. It is important that it does not dry out on either of these surfaces as it will become very sensitive.When handling these types of materials work with small quantities and be aware of any mixing or other forms of agitation that are necessary. Be careful not introduce other substances that will cause a reaction. This may include avoiding the use of metal spatulas and disposing the material in a non-metal container.

When dealing with the physical hazards of powders it's important to avoid dispersal of the material. Static Eliminating Bars can give you more control over powders that are likely to become displaced or electrostatically

charged. More information about this can be found later in this document.

Above we described some of the preliminary considerations necessary for determining an appropriate weighing method. Mostly, this centered on the health and physical hazards – the primary hazard being the fine dust, which is often not visible, that can be generated during handling. This leads to the possibility of inhalation as well as dispersal throughout the work area increasing the risk of exposure and contamination to workers and other processes taking place in the lab. Other factors specific to the chemical also need to be considered. For example, the reactivity of a powder to air or moisture does not necessarily increase the hazards of working with powder but it still may compromise the usefulness of the material and will therefore dictate the handling method.

Physical Properties of Powders

The physical properties are also an important consideration. Some powders are easier to work with than others. Powders that are granular and/or free-flowing and thus pour easily can often be worked with on a bench top with the proper precautions. Other powders do not pour easily or are easily carried away by air currents making them very difficult to work with directly in a fume hood. Certain powders are also subject to electrostatic charge and attempting to transfer the powder with a spatula can lead to a disconcerting dispersal of the material even if there is no air flow.

A special Note on Nanoparticles

Hazardous powders come in a range of sizes and present various risks when they are handled. As a material becomes smaller and finer their characteristics become different from those of their larger counterparts. These differences include health hazards, physical hazards as well as modifications in physical properties. The changes in physical properties that arise as powder sizes decrease include chemical reactivity, magnetic properties, increased surface-area-to-volume ratio and increased structural integrity. These differences are often the reason nanoparticles are used. However, these changes in physical properties have a direct correlation with the increased physical and health hazards of powders. The flammability of many powders increases greatly with the decreased size of these powders. The small size also makes the materials more likely to become charged and more likely to become airborne. And some studies have indicated that up to 100 nm sized particles can pass through the cell membrane while others say particles that are 2 microns or smaller can cross the cells of our lungs and bronchial tubes. When handling nanomaterial it is best to use complete protection, keeping exposure to an absolute minimum.

Options for Weighing

Bench Top

Weighing on a bench top balance is the simplest approach and is appropriate for many situations. If the material's properties allow for easy transfer and will not become airborne bench top weighing is fine. It is necessary to prevent the spread of contamination due to a spill by laying down sheets of disposable paper. Upon completion the paper can be rolled up and placed in a plastic bag before disposal. [**Note: Generally this is acceptable: Contact the Chemical Safety Office for questions on disposal. Additional protection beyond the mandatory eye protection, such as the use of gloves and lab coats, are commonly required – based on the hazard assessment.**]

Fume Hood Option 1:
Direct Weighing in a Fume Hood

If exposure to a chemical must be avoided then the use of a fume hood can be an appropriate control method. Placing a balance directly in the fume hood often works, depending on the required accuracy and the material's properties. However, if a highly accurate measurement is required then this method may prove difficult since often the flow in the fume hood will result in large fluctuations in the readings. Some balances have enclosures that can mitigate this problem. Before weighing your material in a fume hood you'll want to ensure that the airflow isn't too high. Consider that the air flow in the fume hood can cause the powder to become airborne and spread the material over all the surfaces. While the fume hood may provide initial protection from inhalation, this increases the chance of exposure by later coming in contact with contaminated objects.

Fume Hood Option 2
Fume Hood Transfer – Bench Top Weighing

Weighing directly in a fume hood, while beneficial, is not the best option and in some cases the fume hood might not be suitable for your protection. Generally, the finer the particle size is, the easier it is to be disturbed by even the slightest movement of air. Once you have determined a workable airflow with your material you can begin weighing. Below is a basic protocol used for transferring and weighing a hazardous powder.

1. Place your material inside of the fume hood.
2. Set up your scale outside but as close as possible to the fume hood.
3. Pre-weigh a vial, test tube or other covered vessel.
4. Add the compound to your test tube while inside the hood.
5. Take the test tube back to the balance and re-weigh it to calculate the amount added.
6. It may be necessary to add and remove material several times before achieving the desired amount of material.
7. Remember to only handle the powder while inside the hood and keep the lid closed between weighing and adding the powder.
8. Once you've reached your desired amount add solvent to attain the desired concentration.
9. If you are mixing dry compounds, they should be placed in an airtight container or bag to be mixed.
10. If possible, buy your material in pre-weighed amounts and add the contents in a fume hood.

TIP:

The less handling of hazardous chemicals the better. Estimate the amount of powder needed by drawing a fill line on a pre-weighed vial. After transferring powder to the line reweigh the vial to get the exact amount. You can then adjust the amount of solvents and other ingredients to get the concentration you need.

Glove Bag

This method will give you more flexibility and will be faster than weighing in the fume hood since you don't have to go back and forth between weighing and adding powder. This is useful if you are working with highly toxic compounds where exposure is a significant concern. This method can also be used for air-sensitive or air- water-reactive compounds. Glove bags can be set up on counter tops or inside of a fume hood. They are fairly inexpensive and give a few options as to how they are used. They can be disposable and can be thrown away after one use yet durable enough to be reused. Before you start working ensure that your bag is on a sturdy surface and at a comfortable working level. The usual procedure is to use an inert gas to fill the bag completely. Consider the type of work you'll be doing and which gas would be more suitable. If you will be using gas to fill bags attach the gas and insert all necessary equipment into the bag. Once the bag is set up and all of your equipment is inside, seal the bag shut and begin working with your hands inside the sleeves of the glove bag. You can also use a pair of disposable gloves along with the glove bag. This is a good idea if you have Personal Protective Equipment (PPE) needs beyond the glove bag glove or if you have a need for extra dexterity. The bags can also be held open with the use of the equipment that will be used in the procedure. Sigma Aldrich sells a portable lattice system that can be used if inflation isn't needed. For example a balance could be used to hold the bag open. This method will leave some slack in the bag, minimizing the work area. This may not be desirable in certain applications.

Glove Box

A glove box is a completely closed system that allows us to work with hazardous substances without being exposed. They keep dust, fumes, flames and spills isolated away from the worker and the rest of the lab. Glove boxes provide an inert atmosphere. They tend to be expensive and require regular maintenance and training however they provide a high level of protection to the worker and the material. If you have access to one or can borrow usage this may be your best option. For some highly reactive materials this is the most appropriate method for handling them.

Powder Weighing Station

Powder Weighing Stations are hard, compact enclosures used to weigh fine powders and chemicals. They create a precise, horizontal airflow across the work surface. These enclosures are designed to protect the worker as well as the laboratory. Room air is drawn into the opening of the station and through a HEPA filter, removing any particles before the air is dispensed back into the room. The airtight connection between the weighing station and the exterior container prevent this difference from influencing the weighing procedure. Note that these are not fume hoods. Any vapors produced will be recirculated within a room.

Static Eliminating Bar

Static eliminating bars are helpful in preventing powders from clinging to instruments and other objects. Static charge on spatulas can be a nuisance but static charge can also result in weighing errors. An Ionizing Bar is beneficial in such situations. Ionizing bars come in various sizes and some are small enough that they can be adjusted to hang just above your work station ensuring that your powders don't become displaced causing a loss of product. They can also be used to help clean up after powder handling or an accidental spill. Often Ionizing Bars are built with a construction that eliminates any grooves where powders or dust can be trapped causing damage or leaving behind another tool to be cleaned. This is something that is great to have available when working with hazardous powders.

Powders in Solution

Powders that are already dissolved in solution can be handled on the desktop since there is little risk of it becoming aerosolized or inhaled. If, however the solution is being highly agitated you must be aware that this will increase the chances of inhalation as some of the solution becomes aerosolized. In this case it is also necessary to take precaution and work in an appropriate enclosure. A safe practice for working with a hazardous material in solution would be to work over disposable bench covers. If a spill occurs it can be easily cleaned without contaminating the work surface or leaving behind some of the material and it becoming aerosolized after drying. Wear a lab coat to protect yourself from splashes or spills and wear the appropriate gloves. Once the work is finished bench tops should be cleaned with an appropriate cleaning solution or solvent for the material you are working with.

Best Practices and Cleanup

Cleaning up after a powder spill can be difficult. Even a small spill is likely to disperse freely and can become trapped in small cracks and openings. Attempting to sweep or wipe the area can lead to further contamination as the dust is spread around. Preventing a spill on your balance is especially important as it provides many spaces for dust to be trapped.

- Some chemicals such as acrylamide and ethidium
- bromide can be ordered in liquid form or purchase in pre-weighed amounts. Use these when possible.
- Set up and label a designated area for work with toxic powders.
- Cover the work bench or other work surfaces with absorbent bench paper prior to working.
- Use an enclosed balance. This helps keep the working breathing area clear.
- Use weigh boats if you can. They are less likely to spill.
- Keep containers closed as much as possible.
- Avoid pouring powder from bottles as the powder can collect on the neck threads and spill onto the bottles surfaces when the cap is replaced.
- Transfer the powder in several small scoops when possible.
- Work as close as you can to the balance or wherever you will be transferring powders to.
- Anytime the powder is not in use close the container. This will help avoid accidental spillage.
- Identify a standard decontaminating procedure. HEPA vacuuming or wet cleaning methods work best.
- Whenever you clean your vacuum, it should be done in a fume hood.
- Decontaminate the outsides of vials and other equipment as dust may cling to these items.

References and Useful Links

Video on weighing and cleaning powder spills:
http://services.ltc.arizona.edu/MediaServices/risk_management/powder_practices.wvx

Static Elimination Bar
http://www.exair.com/en-US/Primary%20Navigation/Products/Static%20Eliminators/Pages/Ionizing%20Bars.aspx

Here is a link to a video showing how to use a glove box:
http://www.youtube.com/watch?v=RwfNeRiN-u8

Tips and new uses for glove bags:
www.glascol.com/supportdoc/download/id/40

Link to Duke University's Toxic Powders Standard Operating Procedure (SOP)
http://www.safety.duke.edu/OHS/chemsopsTemplates.htm

How Nanoparticles enter the body and their effects:
http://epub.oeaw.ac.at/ita/nanotrust-dossiers/dossier003en.pdf

Prudent Practices in the Laboratory, The National Academies, 2011 pg 141-145.