Science Education Collection

Common Lab Glassware and Uses

URL: https://www.jove.com/science-education/10161

Overview

Source: Laboratory of Dr. Neal Abrams — SUNY College of Environmental Science and Forestry

Glassware is a regular appearance in the professional chemistry laboratory, because it has a relatively low cost, extreme durability, and specific levels of precision. While some labware is being supplemented with plastic or even everyday kitchen materials, glass is still the standard material by which laboratory work is done. While there are few rules about glassware, there are some best practices for use that set the groundwork for good techniques in the lab.

Glass is ubiquitous in the chemistry laboratory, but not all glass is the same. Standard consumer-grade glass is known as "soda-lime" or "float" glass. It is good for many applications, but cracks under rapid heating and cooling applications due to expansion/contraction. Borosilicate glass is used to solve this problem in the lab. Made with an introduction of small amounts of boron, borosilicate glass has a very low coefficient of expansion, which prevents internal stresses. The most common trade name for borosilicate glass is Pyrex, the same type of glass used in some kitchen bakeware.

While borosilicate glass is thermally robust, the impurities found in borosilicate and standard glass lead to a limited temperature range and optical quality. Fused silica, or quartz, is used in situations where glass needs to be heated above 450 °C or to be transparent to UV light. Fused silica is chemically-pure silicon dioxide with no impurities and a very high melting point above 1,600 °C. The easiest way to tell the difference between borosilicate glass and fused silica in the lab is to look down the long axis of a piece of glassware. A greenish color is indicative of borosilicate impurities, whereas fused silica is optically clear and colorless.

Principles

Standard laboratory glassware, like beakers and flasks, has a limited accuracy of measuring volume, typically ±5%. Volumetric glassware, however, is considered very accurate. This accuracy is known to the user through a few different pieces of information on the glassware. For one, an etched line or volume marking is typically located on volumetric glassware to indicate a volume. The next piece of information is the temperature at which the glassware is accurate, typically 20 °C. This is important because the density (and volume) of a liquid are dependent on temperature. Thirdly, the notations "TD" or "TC" are used to indicate "to deliver" or "to contain", respectively. When a piece of glass is marked as "TD", it is calibrated to accurately deliver the stated volume, whereas glassware with the "TC" marking only contains a specified volume, but it may not transfer to another vessel accurately.

Glassware can be sealed using a variety of stoppers, typically rubber, cork, or glass. Rubber and cork stoppers fit into standard glass necks, though cork is being phased out, and newer stoppers made of neoprene are taking over. Stoppers are conical in shape and fit like a wedge into the glassware. Stoppers can have anywhere from 0 – 3 holes, allowing for connections to tubing or inserting thermometers and stirrers. A variation of the stopper is the septum, which can be used to seal glassware and allows for easy access with a syringe needle. The downside of most flexible stoppers is that they break down over time, though newer Teflon stoppers are more robust but lack the physical flexibility. Ground glass stoppers are used to seal flasks that have ground glass fittings. While the seal is very good, glass-to-glass connections are known to seize, so joint grease (vacuum, Krytox, etc.) is often used to prevent this. Rubber stoppers are sized by number, ranging from 000 – 10, whereas glass stoppers are sized by the diameter and length of the sealing section. For example, a stopper marked as 24/40 is 24 mm in diameter at its widest part and 40 mm long on the tapered edge, which would fit into a flask with a 24/40 opening.

Connections between pieces of glassware are made using a variety of ground glass joints including a standard taper, ball-and-socket, and O-ring. The standard taper is the most common fitting. Glass joints are sized to fit into one another and a variety of size adapters are available. Like all other glass joints, grease is required to prevent seizing. While the joint may be sealed, it is not a mechanically strong connection and can fall apart. To prevent glass pieces from separating, connector clips are used, which are sometimes referred to as Keck clips. These clips are color-coded for the size of the joint. Alternatives to connector clips include springs and wire.

Clamping and supporting glassware is a vital part of a successful experiment. While some pieces of glassware, like beakers and Erlenmeyer flasks, have flat bottoms that can sit flat on a hotplate, other pieces of glassware, like round-bottom flasks, need to be supported using clamps. Even with flat-bottom glassware, it can be far too easy for something like a vacuum filtration flask to fall over. Metal clamps are connected to the neck of a piece of glassware using either a three-finger or a standard clamp. The other end of the clamp is then attached to a ring stand (or retort stand). Other clamps exist for special purposes, like chain-style for large pieces or water-bath clamps for thermometers. The lab jack uses a scissoring action to raise or lower a piece of glassware. This is very convenient for large or heavy items and, when used in conjunction with a cork ring, can also be used to move round-bottom flasks.

Just like in the kitchen, soap and water are typically used to clean glassware in the lab. When that fails, organic solvents, like acetone, are sometimes employed to remove sticky and insoluble organic deposits. Even then, some compounds adhere to glassware so well that they are impossible to remove without some form of chemical etching. In the case of organic carbon-containing deposits, glassware can be soaked in a base bath composed of an alcohol (ethanol) and a strong base (sodium hydroxide). This bath etches thin molecular layers of glass from the vessel, taking the stubborn deposits with it. It is very important to never place volumetric glassware in a base bath, which could lead to etching and a change in volume. When a metal has plated or infused into a piece of glassware, an acid bath made with a dilute strong acid, like hydrochloric, is used. The amphoteric nature of glass and the general oxidation of metal in acid lead to its cleaning power. Regardless of the bath type, 24–48 h is required for effective deposit removal.

Procedure

1. Glassware for Qualitative Uses

1. Beakers
    1. The beaker is one of the most common pieces of glassware in the laboratory. It is a simple cylindrical container used to hold solids and liquids with sizes ranging from very small (10 mL) to very large (4,000 mL). It has a lip for ease of pouring and decanting liquids. The graduations are approximate, but very useful when exact volumes are not needed.
2. Flasks
    1. Flasks are designed so the contents can be swirled without spilling. They are also easily fitted with stoppers and often have the stopper size written directly on the flask.
    2. Erlenmeyer Flask
        1. The most common of all flasks, the Erlenmeyer flask has a flat bottom with approximate graduations. The flat bottom allows the Erlenmeyer flask to be directly heated and used in simple reflux (boiling) and condensation procedures.
    3. Florence Flask
        1. The Florence flask is a hybrid between the round bottom and the Erlenmeyer flask and ranges from a few hundred milliliters to a few liters in size. Florence flasks can have either a flat bottom or a round bottom, so applications vary from direct heating to using a heating mantle. It does not have a ground glass joint, so a stopper is used to seal the container. The rounded shape is better for applications that involve boiling.
3. Test Tubes
    1. Test tubes are relatively small cylindrical vessels used to store, heat, and mix chemicals. While the test tube comes in specific sizes, it's typically used in qualitative observational procedures.
4. Watch Glass
    1. The watch glass is used when a high surface area is needed for a small volume of liquid. This is common for crystallizing and evaporating, as well as other qualitative procedures. Watch glasses can also be used as covers for beakers, but not flasks.
5. Crystallization Dish
    1. The crystallization dish is a hybrid between a watch glass and the Petri dish (common in biological procedures). It has a low height-to-width ratio, which means the sides are very low compared to the width of the vessel. This allows for high surface areas for evaporation, but the crystallization dish is more commonly used as a short-term container for liquids in a variety of bath processes (water, acid, or oil).

2. Glassware for Measuring

1. Graduated Cylinder
    1. The graduated cylinder is used to measure a semi-precise volume of liquid. While it is not as precise as volumetric glassware, it is much more accurate and precise than a beaker or flask (to within 1%). Volumes are measured to the bottom of the meniscus for aqueous solutions and the top of the meniscus for non-aqueous hydrophobic solutions. Graduated cylinders are general-use pieces of "TD" glassware, where the delivery volume is important. Higher levels of accuracy require volumetric glassware.
2. Volumetric Glassware
    1. Used for making standardized (high precision) solutions, where precision is known to four significant figures.
    2. Flasks
        1. Volumetric flasks are a mainstay when preparing any standardized solution. Since volumes are not necessarily additive, the volumetric flask is used to make solutions of precise volumes. The etched mark on the neck of the glassware signifies the volume to high precision at the specified temperature. A solution is prepared by adding enough solvent to dissolve the solute, then the solute is added and dissolved. The solution is then diluted to the mark using the solvent. The solution is mixed throughout the dilution process and sometimes requires being placed in an ice bath in the case of exothermic dissolution (typically strong acids or bases). Volumetric flasks range in size from 1 mL to 4,000 mL and larger.
3. Pipettes
    1. Volumetric pipettes are known for high precision, like volumetric flasks, but are used to dispense liquids, typically in the preparation of solutions in a volumetric flask. The pipette also has an etched mark denoting a precise volume, and the solution is drawn into the pipette using a pipette bulb, never by mouth.
4. Micropipettes
    1. Micropipettes are a specialized class of volumetric pipettes used for very small volumes from 1 µl to 1,000 µL. The micropipette uses plastic disposable tips, but these can be re-used under appropriate situations. Most micropipettes have an adjustable range of volumes

using separate withdraw and dispense actions on the pipette body. The mechanism for adjusting, determining volume limits, and ejecting disposable tips varies by manufacturer.

5. Burettes
    1. The burette is an analytical piece of glassware used to dispense variable (but precise) volumes of liquids. Commonly found in analytical chemistry, the burette is used in a variety of titration experiments.

3. Procedural Glassware

1. Round-bottom (Boiling) Flasks
    1. Round-bottom flasks, or boiling flasks, are typically found in synthesis experiments, since the round shape allows for even heating and stirring. The neck typically has a female ground-glass joint and can be attached to condensers and other pieces of glassware. To prevent spills, the solution volume should not exceed 50% of the flask volume. Sizes range from 50 mL to 20,000 mL.

2. Separatory Funnel
    1. While most common to the organic chemistry lab, the separatory funnel is used to separate liquids of different densities and solubilities. The bottom of the separatory funnel is very narrow and leads to a stopcock, allowing for precise separations of liquids, while the top is very wide for ease in shaking and mixing.

3. Filter (Büchner) Flask (used for vacuum filtration)
    1. The filter flask looks like an Erlenmeyer flask, but has a hose barb near the top to attach a vacuum hose. The flask typically has thicker walls than an Erlenmeyer due to the reduced pressure (vacuum) used with the flask. Vacuum (Büchner) funnels fit into the neck of the flask using a rubber collar or a 1-hole rubber stopper.

4. Funnels (used for filtering and transferring)
    1. Traditional funnels used for gravity filtration have a wide cone-shaped body, for adding and filtering solutions, and a long narrow stem, for delivery into a flask. Filter paper is folded into a cone shape, inserted into the funnel, and wetted with a solvent (typically water). The powder funnel has a wider stem designed for dispensing solids and viscous liquids. Filter paper is only used in conjunction with the filter funnel.

5. Ceramics
    1. Büchner Funnel
        1. The ceramic Büchner funnel fits into the filter (Büchner) flask using a rubber cone or 1-hole rubber stopper. The funnel is typically made of ceramic with pin-sized holes in the flat bottom. Filter paper is placed on top of the holes and wetted with solvent (water) to prevent solids from getting under the filter paper.

    2. Crucible
        1. A crucible is made of ceramic and holds small amounts of chemicals during heating at high temperatures. Depending on the specific type, the crucible can withstand temperatures above 1,000 °C and is used in conjunction with a Bunsen burner or furnace. Common uses include heating a hydrated solid to remove water or combusting a compound to determine organic content.

    3. Mortar and Pestle
        1. While the mortar and pestle originated in chemistry (and alchemy) laboratories, it is more common in pharmacology, biology, and culinary applications. Made of ceramic or stone, materials are placed in the bowl-shaped mortar and ground and crushed using the pestle.

Applications and Summary

While there are few rules to how glassware must be used, each piece of glassware was designed for a general set of procedures. Unique situations create some flexibility on the application, and nearly all glassware can be further adapted and customized with the assistance of a professional glassblower.