Identify Your Mineral Treasures

Part Four: Chemical Mineralogy

Equipment, Reagents

Having reviewed the varous *physical* attributes of minerals, it is now time to turn attention to identifying minerals by *chemical* means. Learning these characteristic attributes—and the techniques for ascertaining them—enables the collector and budding mineralogist to better appreciate and enjoy on a deeper emotional level the marvel of mineral collecting.

Attaining a competent knowledge and understanding of mineral identity through research, experience, and experimentation is a distinguishing difference between merely dabbling in a hobby and investing in a life-long passion!

The chemical composition of minerals is of fundamental importance, since all other properties are essentially dependent upon it. A mineral's physical characteristics—its hardness, luster, cleavage, fracture, etc.—are visual manifestations of not only the constituent elements, but also the arrangement of those elements in the crystalline structure.

While the physical characteristics of a mineral may serve as a means of its positive identification—and for most minerals they will be of material assistance—the final proof of the identity of a mineral will often lie in the determination of its chemical nature by implementing various chemical tests. Thus, since the classification of minerals is made on the basis of chemistry, the study of the chemistry of minerals is the most important single division of mineralogy.

EQUIPMENT

To perform these chemical tasks, certain instruments and reagents must be obtained. First and foremost is a source of heat. Back "in the day," use of the blowpipe in the budding field of mineralogy was one of the foundations of low-tech chemical analysis.

The purpose of the blowpipe was, of course, to produce a flame hot enough to fuse a test sample in order to coerce it into revealing its chemical secrets. Mastery of the blowpipe technique could take years to accomplish—more time and effort that I am willing to invest! I've toyed with the piece of equipment to gain a historical perspective, but in reality, its use is simply archaic and unnecessary. A propane torch—cheap and readily available at any hardware or home improvement store—provides perfectly acceptable results. A propane torch accomplishes several very useful and sometimes diagnostic results, the most common of which include determining the fusibility of a mineral, producing flame colors that are distinctive of certain elements, and heating solutions to entice reactions.

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Fusing a sample will often release volatile gases that reveal the chemical constituents that can be detected when the sample is melted on an appropriate substrate. Thus, in concert with the torch, small charcoal blocks are essential accessories. While most of the volatiles yield light deposits, some are much darker, and thus do not show up well on the charcoal blocks. In this case, blocks made of *plaster of Paris* can be made at home to detect those darker substrates.

Other essentials include ¼-inch glass tubing for additional volatility tests, a magnet to reveal magnetic minerals and fused assays, unglazed white tiles for streak tests, mortar and pestle for grinding samples to a powder, platinum wire for making bead tests, litmus and filter papers, pipets, safety glasses, and various sizes of test tubes and holders. A makeshift laboratory will also require additional glassware, such as beakers, flasks, and calibrated cylinders that can be added over time and as finances permit.

A number of tools are also helpful. Files, spatulas, forceps, picks, tweasers, and Exacto knives are just a few. A hardness kit is also helpful, but a homemade one using common items is perfectly adequate. Such a kit will include a penny; small pieces of calcite, quartz, and feldspar; and a steel nail.

With time, experience, and need, other items will inevitably find their way into the inventory. These include plastic storage bottles, dropper bottles, dispenser bottles, test tube brushes, funnels, et al. A spectroscope aids in determining elements revealed in flame tests. Consider obtaining a geiger counter or dosimeter for use in the field and laboratory to reveal and measure levels of radioactivity in many minerals that will certainly be encountered. Most of these items are relatively inexpensive and easy to acquire. Inevitably, however, more expensive equipment must eventually be obtained to fully engage in and appreciate the mineralogy endeavor.

A high-powered stereoscopic microscope is invaluable. Buy the best as financially affordable; the investment will provide a lifetime of rewarding joy and discovery. For example, I own an AmScope 20x-90x zoom microscope with an 8mp digital camera that cost about $800.

Shortwave lights are also expensive, but important for determining flourescence that can be a great aid in identifying minerals, and thereby shorten the experimentation process. Expect to pay upwards of several hundred dollars for very good ones. However, cheaper lights are available, and can be found with a little research. Ebay is a good source. I use a dual-lamp, LW-SW hand-held version that cost about $20 and serves my purpose admirably.

Additional higher-cost items will ultimately be useful. Balance scales to determine the weight of small specimens are handy and inexpensive. On the other hand, balance beams for determining specific gravity (SG) are costly. However, I don't believe such a scale is truly necessary, as specific gravity is difficult to effectively determine since very few specimens found in the field are pure enough to make accurate measurements, and mineral identity tests rarely have to be carried so far as to rely on SG to determine a diagnostic differentiation between candidates.

Consider adding a centrifuge to your lab. Chemical tests often produce precipitates that need to be removed from a solution before continuing the experiment. Having no centrifuge requires days of waiting for the solids to settle to the bottom of the tube before being able to siphon off the remaining clean liquid. I obtained one on Ebay for under $100.

This list is certainly not exhaustive. Without a doubt, circumstances will be encountered that will necessitate obtaining tools and equipment in addition to the ones mentioned thus far.

REAGENTS

(buy the smallest quantities available)

Mineralogists use a variety of chemicals in order to perform tests to determine the chemical constituents of unknown samples. Some of these chemicals are fluxes that dissolve insoluble compounds, others are solvents, and still others are reagents that combine with specific solutes to produce characteristic results. Many of these chemicals occur as solids; others, liquids. Each has its particular hazards, such as toxicity and flammability, that must be carefully addressed when storing and using. It is important to consider the purpose of the test to be performed. For a very generalized test, many of these chemicals need not be of pure lab quality. Depending on the test to be performed and the level of preciseness of the reaction needed for satisfactory results, some off-the-shelf chemicals will do just fine and are usually quite inexpensive, while others need to be of higher quality, requiring a greater financial investment. Thus, depending on the product, some of these chemicals can be considered household items and very easily available, while others are often expensive and difficult to obtain due to legal and shipping requirements.

For example, if the mere presence of carbon dioxide is to be determined, HCl found in pool supply stores as cheap muriatic acid will suffice. On the other hand, specialized reactions requiring more expensive lab-quality reagents, such as dimethyglyoxime to determine the presence of nickel in a test specimen, can only be acquired from chemical supply companies. Still others, like nitric acid, which used to be easy to obtain at any drug store, now can only be shipped to legitimate businesses or academic institutions! However, with a bit of research, ingenuity, and even luck, most of these compounds can eventually become a part of your chemical inventory.

A well-equiped home testing lab need not cost an excessive amount, can be slowly accrued over time, and will provide years of enjoyment and satisfaction. Ideally, such a set up should contain the tools and chemicals reviewed thus far .

WET REAGENTS

Hydrochloric Acid (HCl)

Lab-quality, useful as a solvent for some chemical tests; store-quality, adequate for determining mere presence of CO_2 (carbonate minerals) or simply to dissolve calcite from specimens to reveal/better expose hidden minerals embedded inside. Safe to work with; reasonable handling procedures.

(liquid; for concentrated reagent quality: dilute for use 2 to 3 and 1 to 5 of distilled water)

Nitric Acid (H$_2$NO$_3$)

Strong oxidizing acid; reagent quality preferred; difficult to obtain in other than very small quantity.

(solid; dilute same as for hydrochloric acid)

Sulfuric Acid (H_2SO_4)

Lab-quality acid is oily, hazardous; of limited use, mainly added to HCl solutions to detect presence of calcium; for flame tests, enhances green color imparted to flame by borate assays.

(liquid; dilute 1-6 to distilled water)

Off-the-Shelf:

- **Ammonium Hydroxide (ammonia) (NH_4OH) – dilute 1 to 2 of distilled water**
- **Ethyl Alcohol (C_2H_5OH) – solvent to dissolve dimethyglyoxime**
- **Hydrogen Peroxide (H_2O_2) – used as reagent in tests for titanium, vanadium**

Homemade:

- **Calcium Chloride solution (CaCl) – calcite dissolved in hydrochloric acid**

DRY REAGENTS

Chemical Supply Houses:

Ammonium Molybdate ($(NH_4)_2MoO_4$):	used in the test for phosphorus; very useful
Barium Chloride ($BaCl_2$):	used in the test for sulfate; rarely used
Cobalt Nitrate ($Co(NO_3)_2$):	diluted to use in the tests for zinc and aluminum; usually sold as pink hexahydrate crystals; useful
Cupric Oxide (CuO):	a black compound used in making the flame test for chlorine; rarely needed
Dibasic Sodium Phosphate ($Na_2HPO_4 . 12H_2O$):	complicated test for the presence of magnesium
Dimethylglyoxime ($CH_3\{C(NOH)_2\}CH_3$)	an organic compound used in the test for nickel
Potassium Ferrocyanide ($K_4Fe(CN)_6 . 3H_2O$) and Potassium Ferricyanide ($K_6Fe_2(CN)_{12}$):	used in dilute solutions to test for ferric and ferrous iron, respectively.
Potassium Iodide (KI) and Sulfur (S) mixture (Bismuth Flux):	a mixture of equal parts of these two chemicals used in making the test for bismuth
Potassium Hydroxide (KOH):	used for making the test for aluminum if iron is present
Salt of Phosphorus ($HNaNH_4PO_4 . 4H_2O$):	a white salt used in making bead tests
Silver Nitrate ($AgNO_3$):	diluted to use in the test for chlorine; colorless xls sensitive to exposure to light
Sodium Metaphosphate ($NaPO_3$):	a white salt used in making the test for fluorine
Tin (Sn):	used in granular form to make reduction tests in hydrochloric acid solutions
Zinc (Zn):	same as for tin; can also be acquired from old battery casings

Off-the-Shelf:

Borax ($Na_2B_4O_7 . 10H_2O$):	a white salt used chiefly in making bead tests
Oxalic Acid ($C_2H_2O_4 . 2H_2O$)	dissolved in water to make solutions for cleaning iron stains from specimens; (buy 5 lbs at a time)
Sodium Carbonate (Na_2CO_3):	a white salt used as a flux to decompose minerals by fusion on charcoal, and more rarely as a bead-test flux

None of these chemicals have particularly hazardous qualities, nor require much more than reasonable storage in dry, cool—and in the case of silver nitrate—dark environments.

Remember to always add *acids to water*, NEVER *water to acid*!

Next issue will continue with **Testing Techniques**