# Chemical Storage and Handling Recommendations

**Improper storage of laboratory chemicals can present a potential safety hazard for school science departments. One solution is to separate chemicals into their organic and inorganic families and then to further divide the chemicals into related and compatible families[1]. Table 1 and Table 2 (below) demonstrate compatible family groupings. Chemicals organized for compatible storage markedly increase safety for students and school employees.**

**Handling school chemicals safely is completely at the risk and entirely the responsibility of the school officials. It is always a good practice to consult its SDS[2] when handling any chemical.**

**Table 1. Flinn Suggested Compatible Family Codes and Shelf Storage Pattern - Inorganic (I)[3]**

| | |
|---|---|
| **Inorganic #10 (I10)**<br>Sulfur, Phosphorus, Arsenic, Peroxide | **Inorganic #7 (I7)**<br>Arsenates, Cyanides, Cyanates<br>(Store away from any water) |
| **Inorganic #2 (I2)**<br>Acetates, Halides, Halogens, Oxalates, Oleates, Phthalates, Phosphates, Sulfates, Sulfites, Thiosulfates | **Inorganic #5 (I5)**<br>Sulfides, Selenides, Phosphides, Carbides, Nitrides |
| **Inorganic #3 (I3)**<br>Amides, Nitrates (except Ammonium Nitrate), Nitrites, Azides<br>(Isolate Ammonium Nitrate and store away from all other substances) | **Inorganic #8 (I8)**<br>Borates, Chromates, Manganates, Permanganates, Molybdates, Vanadates |
| **Inorganic #1 (I1)**<br>Metals, Hydrides (Store away from any water)<br>(Store flammable solids in flammables cabinet) | **Inorganic #6 (I6)**<br>Bromates, Chlorates, Chlorites, Iodates, Peroxides, Hydrogen Peroxide, Hypochlorites, Perchlorates, Perchloric Acid |
| **Inorganic #4(I4)**<br>Hydroxides, Oxides, Silicates, Carbonates, Carbon | **Miscellaneous (IM)**<br>Inorganic Miscellaneous |

| |
|---|
| **Inorganic #9 (I9)**<br>Acids, Except Nitric Acid (Nitric Acid is isolated and stored by itself)<br>(Acids are best stored in a dedicated and locked cabinet) |

**Table 2. Flinn Suggested Compatible Family Codes and Shelf Storage Pattern - Organic (O)[4]**

| | |
|---|---|
| **Organic #2 (O2)**<br>Alcohols, Glycols, Sugars, Amines, Amides, Imines, Imides<br>(Stored flammables in a dedicated cabinets) | **Organic #8 (O8)**<br>Phenols, Cresols |
| **Organic #3 (O3)**<br>Hydrocarbons, Esters, Aldehydes, Oils<br>(Store flammables in a dedicated cabinet) | **Organic #6 (O6)**<br>Peroxides, Hydroperoxides, Azides |
| **Organic #4 (O4)**<br>Ethers, Ketones, Ketenes, ethylene Oxide, Halogenated Hydrocarbons (Stored flammables in a dedicated cabinet) | **Organic #1 (O1)**<br>Acids, Amino Acids, Anhydrides, Peracids<br>(Store certain organic acids in acid cabinet) |
| **Organic #5 (O5)**<br>Epoxy Compounds, Isocyanates | **Organic #9 (O9)**<br>Dyes, Stains, Indicators<br>(Store alcohol-based solutions in flammables cabinet) |
| **Organic #7 (O7)**<br>Sulfide, Polysulfides, etc. | **Miscellaneous (OM)**<br>Organic Miscellaneous |

Organic #2 (Alcohols, Glycols etc.); Organic #3 ( Hydrocarbons, etc.)
Organic #4 (Ethers, Ketones, etc.); Organic #9 (Alcohol-based Indicators, etc.)
Should be stored in a flammables cabinet

# Potential Risks for Storage or Mixing of Incompatible Chemicals

**When certain chemicals are stored or mixed together, violent reactions may occur because the chemicals are unsuitable for mixing or are incompatible. No single method of determining chemical compatibility is perfect. The reasons are varied, however the main cause is that many chemicals belong to more than one hazard class. This can lead to confusion as to which class is appropriate for the chemical in question. The hazard class can change depending on factors such as quantity of chemicals and other chemicals in the storage area. Not all chemicals in a given class are compatible. For example: sodium dichloroisocyanurate and calcium hyperchlorite are both oxidizers, yet the mixing of these two chemicals can lead to the formation of nitrogen trichloride, a shock sensitive explosive. The sheer number of exceptions to any classification scheme prevents listing all of them in a convenient reference table.**

**The mixing of incompatible chemicals in a waste container can form an explosive mixture. If a bottle breaks in a waste storage area where incompatibles are/were present, the results could be disastrous. Remember, incompatible bottles of waste chemicals should be stored separately. The objective is to avoid accidents in the laboratory.**

**The chemicals listed in Table 3, Table 4, and Table 5 are not intended to be all inclusive and should not be considered complete. They include only the most common incompatible combinations. The absence of a chemical from this list should not be taken to indicate that it is safe to mix it with any other chemicals! (consult a chemical's SDS for additional guidance).**

**The chemicals listed in the following table react violently when they come into contact with each other and must not be stored together.**

**Table 3. Common Incompatible Chemical Combinations[5]**

| Chemicals | Incompatible with |
|---|---|
| Acetic acids | Chromium oxide, nitric acid, perchloric acid, peroxides, permanganates, alcohol, ethylene glycol |
| Acetic anhydride | Hydroxyl-containing compounds e.g. ethylene glycol, perchloric acid |
| Acetone | Concentrated nitric acid and sulfuric acid mixtures, hydrogen peroxide |

| | |
|---|---|
| Acetylene | Chlorine, bromine, fluorine, copper, silver |
| Activated carbon | Calcium hypochlorite, oxidizing agents |
| Alkali metals | Water, carbon tetrachloride and other halogenated alkanes, carbon dioxide, halogens. (Do not use water or foam extinguishers for fires involving these metals use the appropriate Class D extinguisher. |
| Aluminum | All oxidizing agents, acids, alkalis, halogenated hydrocarbons, peroxides |
| Aluminum alkyls | Water |
| Ammonia, liquid or gas | Chlorine, calcium hypochlorite, iodine, bromine, hydrogen fluoride |
| Ammonium nitrate | Acids, powdered metals, flammable liquids, chlorates, nitrates, sulfur, fine-particulate organic or combustible materials |
| Aniline | Nitric acid, hydrogen peroxide |
| Arsenic materials | Any reducing agent |
| Azides | Acids |
| Bromine | See Chlorine |
| Calcium carbide[6] | Water, ethanol |
| Calcium oxide | Water |
| Carbon activated | Calcium hypochlorite, other oxidants |
| Carbon tetrachloride[7] | Sodium |
| Chlorates | Ammonium salts, acids, powdered metals, sulfur, fine-particulate organic or combustible substances |
| Chlorine | Ammonia, acetylene, butadiene, butane, methane, propane, hydrogen, petroleum benzine, benzene, powdered metals |
| Chlorine dioxide[7] | Ammonium, methane, phosphine, hydrogen sulfide |
| Chromium (V1) oxide, Chromic acid | Acetic acid, naphthalene, camphor, glycerol, petroleum benzine, alcohols, flammable liquids |
| Copper | Acetylene, hydrogen peroxide |

| | |
|---|---|
| Cumene Hydroperoxides | Acids, both organic and inorganic |
| Cyanides | Acids |
| Flammable liquids | Ammonium nitrate, chromium (VI) oxide, hydrogen peroxide, nitric acid, sodium peroxide, halogens, chromic acid. |
| Fluorine | Extremely aggressive; store separately! Isolate from everything! |
| Hydrazine | Hydrogen peroxide, nitric acid, any other oxidant |
| Hydrocarbons, butane, propane, benzene etc. | Fluorine, chlorine, bromine, chromium (VI) oxide, sodium peroxide |
| Hydrocyanic acid[7] | Nitric acid, alkali |
| Hydrogen fluoride (hydrofluoric acid) | Ammonia (laboratory gas or solutions) |
| Hydrogen peroxide | Copper, chromium, iron, metals and metal salts, alcohols, acetone, organic substances, aniline, nitromethane, combustible substances (solid or liquid) |
| Hydrogen sulphide | Fuming nitric acid, oxidizing gases |
| Hypochlorites | Acids, activated carbon |
| Iodine | Acetylene, ammonia (laboratory gas or solutions) |
| Mercuric oxide[6] | Sulfur |
| Nitrates and nitrites | Acids |
| Nitric acid | Acetic acid, aniline, chromium (VI) oxide, prussic acid, hydrogen sulfide, flammable liquids and gases |
| Nitrites[7] | Acids |
| Nitroparaffins | Inorganic bases, amines |
| Oxalic acid | Silver, mercury salts |
| Oxygen[7] | Oils, grease, hydrogen; flammable liquids, solids, or gases |
| Perchloric acid | Acetic anhydride, bismuth and its alloys, alcohols, paper, wood, grease. oil, (all organics) |

| | |
|---|---|
| Peroxides, organic | Acids (organic and inorganic), avoid friction, store cold |
| Phosphorus | Sulfur, compounds containing oxygen, e.g. chlorates, air, oxygen |
| Phosphorus (white)[6,7] | Air, oxygen, alkalis, reducing agents, carbon tetrachloride, carbon dioxide, water, alcohols, acids |
| Phosphorus pentoxide | Alcohols, strong bases, water |
| Potassium | Air, oxygen, reducing agents, Carbon tetrachloride, carbon dioxide, water, alcohols, acids |
| Potassium chlorates | See Chlorates |
| Potassium perchlorate | See Chlorates |
| Potassium permanganate | Glycerol, ethylene glycol, benzaldehyde, sulfuric acid |
| Selenides[7] | Reducing agents |
| Silver | Acetylene, oxalic acid tartaric acid, ammonium compounds |
| Sodium | See Alkali metals |
| Sodium Nitrate[6] | Ammonium salts |
| Sodium Nitrite[7] | Ammonium nitrate and other ammonium salts |
| Sodium peroxide | Methanol, ethanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfural |
| Sulfides (sulphides) | Acids |
| Sulfuric acid | Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium) |
| Sulphur | Metals, all oxidizing agents |
| Tellurides[7] | Reducing agents |
| Zinc | All oxidizing agents, acids, alkalis, halogenated hydrocarbons, peroxides |

**Table 4. Possible Reactions That May Occur Due to Improper Storage of Incompatible Chemicals[5]**

| Chemicals Stored Together | Possible Reaction |
|---|---|
| Acetic acid & acetaldehyde | Small amounts of acetic acid will cause the acetaldehyde to polymerize, releasing heat |
| Acetic anhydride & acetaldehyde | Reaction can be violently explosive |
| Aluminum metal & ammonium nitrate | A potential explosive |
| Aluminum & bromine vapor | Aluminum foil reacts with bromine vapor at room temperature and combusts |
| Ammonia vapor & bromine vapor | Unstable nitrogen tribromide is formed, explosion may result |
| Ammonium nitrate & acetic acid | A mixture may result in ignition, especially if acetic acid is concentrated |
| Cupric sulfide & cadmium chlorate | Will explode on contact |
| Hydrogen peroxide & ferrous sulfide | Forms a vigorous, highly exothermic reaction |
| Hydrogen peroxide & lead II or IV oxide | Violent, possibly explosive reaction |
| Lead perchlorate & methyl alcohol | Forms an explosive mixture if agitated |
| Lead sulfide & hydrogen peroxide | Vigorous, potentially explosive reaction |
| Mercury II nitrate & methanol | May form mercury fulminate - an explosive |
| Nitric acid & phosphorus | Phosphorus burns spontaneously in the presence of nitric acid |
| Potassium cyanide & potassium peroxide | A potentially-explosive mixture if heated |
| Sodium nitrate & sodium thiosulfate | A mixture of the dry materials can result in an explosion |

**Table 5. Potentially Explosive Combinations of Common Reagents[7]**

| |
|---|
| Acetone + Chloroform in the presence of base |
| Acetylene + Copper, Silver, Mercury salts |
| Carbon Disulfide + Sodium Azide |
| Chlorine + an Alcohol |
| Chloroform or Carbon Tetrachloride + Powdered Aluminum or Magnesium |
| Decolorizing Carbon + an Oxidizing Agent |
| Diethyl Ether + Chlorine (including a chlorine atmosphere) |
| Dimethyl Sulfoxide + Chromium Trioxide |
| Ethanol + Calcium Hypochlorite |
| Ethanol + Silver Nitrate |
| Nitric Acid + Acetic Anhydride or Acetic Acid |
| Picric Acid + a heavy metal salt such as Lead, Mercury, or Silver Oxide + Ammonia + Ethanol |
| Sodium + a Chlorinated Hydrocarbon |
| Sodium Hypochlorite + an Amine |

# Federal Regulations on Iodine[8]

### Drug Enforcement Administration (DEA); 21 CFR Parts 1309 and 1310 (Rules - 2007)

**This rulemaking establishes regulatory controls that will apply to iodine crystals and iodine chemical mixtures that contain greater than 2.2 percent iodine. Persons handling regulated iodine materials are required to register with DEA, are subject to the import/export notification requirements of the Controlled Substances Act (CSA), and are required to maintain records of all regulated transactions involving iodine regardless of size.**

**Crystal Iodine is commonly found in chemical storage rooms of high schools. Make sure you know that it is federally regulated.**

## Reference:


1. Flinn's "Scientific Catalog Reference Manual", 2012 and its Safety Data Sheet (SDS) on Line: http://www.flinnsci.com/msds-search.aspx

2. SDS: Safety Data Sheet

3. Flinn Inorganic Compatible Family Codes (I1 to I10 and IM);  Flinn's "Scientific Catalog Reference Manual", 2012, p1167

4. Flinn Organic Compatible Family Codes (O1 to O9 and OM); Flinn's "Scientific Catalog Reference Manual", 2012, p1167

5. Analytical Chemistry Resources; http://delloyd.50megs.com/moreinfo/storage.html

6. University of Notre Dame, Risk Management and Safety Website: http://riskmanagement.nd.edu/.../incompatible_chemicals.pdf%22%3Eincompa..

7. University of New Hampshire website: http://www.unh.edu/.../Chemical%20Inco...Univ; (Manufacturing Chemist's Association, Guide for Safety in the Chemical Laboratory, pp. 215-217)

8. U.S. Department of Justice, Drug Enforcement Administration on Line: http://www.deadiversion.usdoj.gov/fed_regs/rules/2007/fr0702.htm