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Chemical Storage: Categories, Hazards And Compatibilities

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Overview

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While the use of various chemicals in experimental research is essential, it is also important to safely store and maintain them as a part of the Environmental, Health and Safety (EHS) program. The properties of chemicals and their reactivity vary broadly and if chemicals are not managed, stored, and labeled properly, they can have harmful or even destructive consequences such as toxic fume production, fire or explosion, which may result in human fatality, property damage or environmental hazards. Therefore, an appropriate chemical label should identify the material and list the associated hazards, and users should have knowledge of how to read chemical labels and safety data sheets (SDS). Proper chemical storage must meet OSHA (Occupational Safety and Health Association) standards and this can prevent most chemical reactivity hazards.

Principles

Chemical storage begins with proper chemical labeling, which identifies the chemical and indicates what chemical hazards are associated to anyone who handles, uses, stores or transports. The National Fire Protection Association (NFPA) diamond symbol rates the degree of health (blue), flammability (red), reactivity (yellow), and special hazards (white) of chemicals. Hazards are rated from zero for no hazard to 4 for severe risk. Chemicals must then be segregated according to their chemical family or hazard classification, and stored appropriately so that any incompatibility is avoided. SDS are detailed documents which cover more topics relevant to safety than labels, and therefore SDS should be consulted to ensure thoroughly safe handling of hazardous chemicals.

Procedure

1. Labeling for Hazardous Material

1. Collect information on hazards from applicable sections of the safety data sheet (SDS) for the chemical. Some SDSs may even provide the NFPA 704 diamond symbol with hazard rating numbers filled in already.
2. If the SDS does not provide a NFPA diamond label for the chemical, the information may be obtained under the following sections of the SDS:
 - Health hazard information under Section 11
 - Flammability information under Section 9
 - Instability information under Section 10
 - Special information under Section 9, 10, 11
 Check other sections of the SDS for additional information.
3. Compare the SDS criteria with the current edition copy of NFPA 704 criteria shown in:
 - Table 5.2 Degrees of Health Hazards
 - Table 6.2 Degrees of Flammability Hazards
 - Table 7.2 Degrees of Instability Hazards
 - Table 8.2 Degrees of Special Hazards
4. Once the numbers for the degree of hazard associated with the criteria are determined, place in the correct quadrant of NFPA 704 placard.
5. The Hazard Communication Standard, 29 CFR 1910.1200 requires all manufacturers, importers, and distributors of hazardous materials to label chemicals with the following information: product identifier, signal word, hazard statement(s), precautionary statement(s) and pictogram(s), and name, address and telephone number of the material manufacturer, importer or distributor.
6. The product identifier can include the name and alternate names of the material, a code, such as the CAS number, and the product batch number.
7. The signal word is to indicate the level of the hazard and can only be 'warning' or 'danger'. 'Warning' means less severe, 'danger' means more severe.
8. A hazard statement describes the hazard of the material. Hazard statements are always written the same for a given hazard, for example, 'May cause allergy or asthma symptoms or breathing difficulties if inhaled'. The only acceptable alterations to hazard statements are if multiple hazard statements are combined to improve readability.
9. There are four types of precautionary statements: prevention, response, storage, and disposal. A prevention precautionary statement is aimed at minimizing risk, for example, 'handle under inert gas'. A response precautionary state is included in the case of a spill or exposure to the material, for example, 'take off immediately all contaminated clothing'. An example of a storage precautionary statement is 'protect from sunlight'. An example of a disposal precautionary statement is 'dispose of contents/container to comply with applicable local, national and international regulation.'

2. Segregate Incompatible Chemicals

1. Chemicals should always be segregated and stored according to their incompatible chemical and physical characteristics. Basic hazard groups include:

1. Acids
 2. Bases
 3. Flammables
 4. Oxidizers
 5. Toxics
 6. Peroxide forming chemicals
 7. Pyrophoric forming substances
 8. Water reactive chemicals
 9. Explosives
2. Below are some common hazard groups to segregate:
 1. No acids with bases
 2. No bases with acids
 3. No acids or bases with flammables
 4. No oxidizers near compressed flammable gases
 3. Incompatible chemicals must not be stored in close proximity to each other. In an emergency situation of a fire, earthquake or a spill, incompatible chemicals could mix and react to cause toxic fume production or an explosion.

3. Chemical Storage Method

1. Chemicals should be stored according to their incompatible chemical and physical characteristics. Alphabetical storage may be used within a compatible chemical group but never as a chemical storage plan for an entire inventory.
2. Chemicals must be stored in accordance to the manufacturer's directions or SDS instructions.
3. Liquid chemicals should not be stored over shoulder height to ensure easy access and handling and be stored in chemically resistant secondary containers in case there is a leak or spill.
4. Chemicals containers should be stored with closed and properly fitted caps.
5. Acids and bases should be stored separately and stored in acid cabinets or on protected shelves which are not metal in order to avoid corrosion
6. Flammable and combustible chemicals must be stored in approved flammable storage cabinets and kept away from any ignition source, oxidizers, or corrosives. Flammable storage cabinets should be properly vented into the building's dedicated vent system. Laboratory-grade flammable-safe refrigerators should be used when flammable chemicals require refrigeration. Do not store food or beverages in the laboratory refrigerator.
7. Toxic chemicals should be stored in a ventilated, cool, and dry area.
8. Peroxide forming chemicals must be dated upon delivery and opening, and must be disposed before the expected date of initial peroxide formation and be stored in a dark, cool, and dry area.
9. Air and water must be removed rigorously from containers of pyrophoric forming substances and should be stored away from flammables in a cool and dry area.
10. Explosives should be stored away from all other chemicals in a secure location and away from shock or friction.

4. Safety Data Sheets

Note: The purpose of the SDS is to provide an easy to understand, standardized document that informs the user of important information regarding the material. OSHA requires manufacturers, distributors, and importers to provide SDSs to end-users of hazardous materials (Hazard Communication Standard 29 CFR 1910.1200(g)). The SDS is a 16 section document containing details on properties, hazards, storage and transport, regulatory status, protective measures, and emergency procedures. The following is an outline of the 16 sections in an SDS.

1. Section 1: Identification: This section provides the name and alternate names of the material along with suggested uses, restrictions and contact information of the supplier.
2. Section 2: Hazard identification: Hazards associated with the material are identified in this section. Hazard symbols may be shown along with a description of the hazard.
3. Section 3: Composition/information on ingredients: For substances, this sections contains the chemical name, alternative names and identifiers, CAS number, impurities and additives. For mixtures, the same information for substances is provided for all components of the mixture. The percentage of each component is specified, except in the case of trade secrets. If chemical composition has been withheld due to trade secret, this must be stated. Toxicology data is provided for each hazardous substance in the material (lethal dose/lethal concentration, etc).
4. Section 4: First-aid measures: In the event of exposure (skin and eye contact, inhalation, or ingestion) to the material, this section states the first response procedures for untrained personnel. The effects, acute and delayed, are detailed.
5. Section 5: Fire-fighting measures: Appropriate and inappropriate extinguishing equipment, and recommended protective firefighting equipment is stated. Hazardous combustion products are listed.
6. Section 6: Accidental release measures: Procedures and methods for handling spills and leaks are outlined in this section. Personal precautions, emergency procedures containment methods and cleanup procedures are covered.
7. Section 7: Handling and storage: This section provides information on safe handling and storage of the material. Safe handling and storage conditions are outlined, including incompatibilities and hygiene practices.
8. Section 8: Exposure controls/personal protection: This section outlines exposure limits and engineering controls (e.g., ventilation system, glove box) and PPE (e.g., glove type, apron, face protection) that can be used to prevent exposure to the material.
9. Section 9: Physical and chemical properties: This section contains information regarding the physical and chemical properties of the material. The minimum information this section must require is state (gas, liquid, solid), color, odor, odor threshold, melting point, boiling point, density,

vapor density, viscosity, vapor pressure, evaporation rate, pH, upper and lower flammability limits, upper and lower explosive limits, auto-ignition temperature, flash point, flammability, decomposition temperature, octanol-water partition coefficient, and solubility.

10. Section 10: Stability and reactivity: This section provides information on the reactivity of the material under specific conditions, incompatibilities and conditions that should be avoided.
11. Section 11: Toxicological information: This section contains information on the toxicology and health effects of the material. This includes effects and symptoms of acute and chronic exposure, routes of exposure (skin and eye contact, inhalation, or ingestion) and LD50/LC50 data. LD50/LC50 (lethal dose, 50%/lethal concentration, 50%) is the dose/concentration required to kill 50% of the exposed population in a set time frame.
12. Section 12: Ecological information: (non-mandatory) This section includes information on the environmental impact of the material. If available, data on aquatic and terrestrial organisms should be provided.
13. Section 13: Disposal considerations (non-mandatory): This section contains information on appropriate disposal of the material and items contaminated with the material, including appropriate containers and methods.
14. Section 14: Transport information (non-mandatory): This section outlines the transportation and shipping requirements of the material. Information includes the UN number, UN shipping name, transport hazard class, packing group number, relevant environmental hazards and any material specific instructions.
15. Section 15: Regulatory information (non-mandatory): This section details any regulatory information regarding the material or components of the material.
16. Section 16: Other information: This section notes when the SDS was last revised and any changes since the first revision.

Results

RGN	Reactivity Group	Incompatible With RGN:
1	Acids, Mineral, Non-Oxidizing	4-15,17-26,28,30-34,101-107
2	Acids, Mineral, Oxidizing	3-34,101-103,105-107
3	Acids, Organic	2,4,5,7,8,10-12,15,18,21,22,24,265,33,34,102-105,107
4	Alcohols and Glycols	1-3,8,18,21,25,30,34,104,105,107
5	Aldehydes	1-3,7,8,10,12,21,25,27,28,30,33,34,104,105,107
6	Amides	1,2,21,24,104,105,107
7	Amines, Aliphatic and Aromatic	1-3,5,12,17,18,21,24,30,34,104,105,107
8	Azo Compounds, Diazo Compounds and Hydrazines	1-5,9,11-13,17-23,25,30-34,102-107
9	Carbamates	1,2,8,10,21,22,25,30,104,107
10	Caustics	1-3,5,9,13,17-19,21,22,24-27,32,34,102,103,107
11	Cyanides	1-3,5,9,13,17-19,21,22,24-27,32,34,102,103,107
12	Dithiocarbamates	1-3,8,17-19,21,25,30,34,103,104,107
13	Esters	1,2,8,10,21,25,102,104,105,107
14	Ethers	1,2,104,107
15	Fluorides, Inorganic	1-3,107
16	Hydrocarbons, Aromatic	2,104,107
17	Halogenated Organics	1,2,7,8,10,11,20-23,25,30,104,105,107
18	Isocyanates	1-4,7,8,10-12,20-22,25,30,31,33,104-107
19	Ketones	1,2,8,10,11,20,21,25,30,104,105,107
20	Mercaptans and Other Organic Sulfides	1,2,8,17-19,21,22,25,30,34,104,105,107
21	Metals, Alkali and Alkaline Earth Elemental	1-13,17-20,25-27,30-32,34,101-104,106,107
22	Metals, Other Elemental and Alloys as Powders, Vapors or Sponges	1-3,8-10,17,18,20,28,30,34,102-104,106,107
23	Metals, Other Elemental and Alloys as Sheets, Rods, Drops, Moldings	1,2,8,17,102-104,107
24	Metal and Metal Compounds, Toxic	1-3,6,7,10,26,30,34,102,103,106,107
25	Nitrides	1-5,8-13,17-21,26-27,30,31,34,101-104,106,107
26	Nitrites	1-3,10,21,24,25,30,104,105,107
27	Nitro Compounds, Organic	2,5,10,21,25,104,105,107
28	Hydrocarbons, Aliphatic, Unsaturated	1,2,5,22,30,104,107
29	Hydrocarbons, Aliphatic, Saturated	2,104,107
30	Peroxides and Hydroperoxides, Organic	1,2,4,5,7-9,11,12,17-22,24-26,28,31-34,101-105,107
31	Phenols and Cresols	1,2,8,18,21,25,30,34,102-105,107
32	Organophosphates, Phosphothioates, Phosphodithioates	1,2,8,10,21,30,34,104,105,107
33	Sulfides, Inorganic	1-3,5,8,18,30,34,102-104,106,107
34	Epoxides	1-5,7,8,10-12,20-22,24,25,30-33,102,104,105,107
101	Combustible and Flammable Materials, Misc.	1,2,21,25,30,102,104,105,107

102	Explosives	1-3,8,10,13,21-25,30,31,33,34,101,105-105,107
103	Polymerizable Compounds	1-3,8,10-12,21-25,30,31,33,102,104,105, 107
104	Oxidizing Agents, Strong	1,3-9,11-14,16-23,25-34,101-103,105, 107
105	Reducing Agents, Strong	1-8,12,13,17-20,26,27,30,31,32,34,101-104,106,107
106	Water and Mixtures Containing Water	1,2,8,18,21,22,24,25,33,105, 107
107	Water Reactive Substances	ALL!

Table 1. Chemical compatibility chart. Obtained from Penn State Environmental Health and Safety website at http://legacy.ehs.psu.edu/hazmat/chemical_compatibility.cfm

Applications and Summary

Research laboratories often contain many chemicals that may pose distinct hazards to our health and well-being. Proper storage, maintenance, and labeling of these chemicals can help prevent accidents and provide a safe working environment. While the list of chemicals may vary by laboratory and experiments, this document provides a basic guideline to storing and maintaining chemicals, and using the SDS to properly handle chemicals. Specific hazard assessment may reveal more specialized and additional storage requirements.

References

1. Quick Card National Fire Protection Association at http://www.nfpa.org/Assets/files/AboutTheCodes/704/NFPA704_HC2012_QCard.pdf
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3. Occupational Health and Safety (OSHA) Regulations (Standards - 29 CFR) 1926.152 - Flammable liquids at [https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10673#1926.152\(a\)](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10673#1926.152(a))
4. NFPA 30: Flammable and Combustible Liquids Code at <http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards?mode=code&code=30>
5. Occupational Health and Safety (OSHA) National Research Council Recommendations Concerning Chemical Hygiene in Laboratories Standard-1910.1450 App A at https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10107
6. OSHA, Hazard Communication Standard, 29 CFR 1910.1200, 2012
7. Globally Harmonized System of Classification and Labelling of Chemicals (Second revised ed.), New York and Geneva: United Nations, 2007, ISBN 978-92-1-116957-7, ST/SG/AC.10/30/Rev.2 ("GHS Rev.2")