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Compatibility Guide for Hazardous Materials in Laboratories

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ABSTRACT

Chemicals are hazardous materials which may cause a significant risk to health and treating human life if not stored according to safety rules. Storing chemicals must be based mainly on the compatibility concept. The best way to store chemicals safely is by keeping them in compatible containers using special chemical storage cabinets. In case of container failure due to incompatible container or stopper a hazardous chemical reactions can occur resulting a hazardous products. In addition to, the correct material for package is important to ensure product compatibility. In this article, many observations including examples of chemical containers that are not compatible with the nature of the chemicals stored in them thus increasing the risk of unexpected reactions. In case of the original material is subdivided, it is important to choose a container with the same specifications as the original container and installing its information data on the new container. An important recommendation stated in this article can be used as a guide in storing chemicals.

Keywords: *Chemical compatibility, chemical container, storage chemicals, risk*

INTRODUCTION

Hazardous chemicals in the workplace are substances, mixtures and materials that can be classified according to their health and physicochemical risks and dangers [1-3].It has been found that most industrial fires are caused by incorrectly stored chemicals and other flammable liquids. The first line of defense is to keep chemicals in high quality containers to begin with. However, to reduce the hazard of some common problems due to leaking or spilling flammable liquids, you need to create additional protective layers in order to safeguard your work place.

It has been largely explained that proper storage of chemicals must be highly considered as a crucial factor in every precautionary protocol of safety [4, 5]. In this article, we present some of our observations during to an inspection to one of the research laboratories. Along with these observations, we discuss the adverse effects of the inconvenient and unsafe storage for these chemicals as well as some suggestions to have a reasonably safe working laboratory.

Choosing a Storage Container

As a matter of fact, due to the importance of safe chemical storage, we believe that we should remind those who have already spent years of experience in laboratories as well as less experienced people. It is quite important to know the class of the substance to be stored and then decide whether a glass or plastic container would be suitable to it or not.

It is quite important to know that chemicals in their original bottles must be kept there without transfer into another bottle or container.

These original bottles are specially designed and made for these specific substances. However, if they have been transferred for some reasons, then it recommended to follow the following guidelines (Table 1).

Table1. *General guidelines selecting the correct material for chemicals packaging*

Chemical Category	Container Type
Mineral Acids	Plastic
Bases	Plastic
Oxidizers	Glass
Organics, including acetic acid	Glass

Advances in polymeric material research have contributed to development of container materials which meet the requirements of handling of different laboratory chemicals.

Plastic materials have contributed to convenience of large-scale automation and material handling capabilities of laboratory samples [6]. See figure 1.

Plastic Material: / Chemical Family	Teflon*	HDPE	LDPE	PC	PETG	PP	PVC
Acids (diluted/ weak)	E	E	E	E	G	E	E
Acids* (strong/ concentrated)	E	G	G	G	N	G	G
Alcohols (aliphatic)	E	E	E	G	G	E	G
Aldehydes	E	G	G	G	G	G	G
Alkalis (bases)	E	E	E	N	N	E	E
Esters	E	G	G	N	G	G	N
Hydrocarbons (aliphatic)	E	G	F	G	G	G	G
Hydrocarbons (aromatic)	E	N	N	N	N	N	N
Hydrocarbons (halogenated)	E	N	N	N	N	N	N
Ketones (aromatic)	E	N	N	N	N	N	F
Oxidising Agents (strong)	E	F	F	F	F	F	G

*for oxidising acids, see Oxidising Agents (strong)

	Compatibility
E	Excellent. 30 days of constant exposure caused no damage. Plastic may tolerate the chemical for years.
G	Good. Little or no damage after 30 days of constant exposure to the chemical.
F	Fair. Some effect after seven days of constant exposure to the reagent. Effects include crazing, cracking, loss of strength or discolouration.
N	Not recommended. Immediate damage may occur. Depending on the plastic, the effect may be crazing, cracking, loss of strength, discolouration, deformation, dissolution or permeation loss.

HDPE	High Density Polyethylene
LDPE	Low Density Polyethylene
PC	Polycarbonate
PETG	Polyethylene Terephthalate Copolyester
PP	Polypropylene
PVC	Polyvinyl Chloride

Figure1. *A container material compatibility chart for commonly used polymer types [6]*

Effects of Chemicals on Plastics

Chemicals can affect the strength, flexibility, surface appearance, color, dimensions or weight of plastics. The basic modes of interaction which cause these changes are: (1) chemical attack on the polymer chain, with resultant reduction in physical properties, including oxidation; reaction of functional groups in or on the chain, and de polymerization; (2) physical change, including absorption of solvents, resulting in softening and swelling of the plastic; permeation of solvent through the plastic, and dissolution in a solvent, and (3) stress-cracking from the interaction of a "stress-cracking agent" with molded-in or external stresses. It must be taken in consideration not to store strong Oxidizing agents in plastic lab ware except that made of FEP or PFA. Prolonged exposure causes embrittlement and failure. While prolonged storage may not be intended at time of filling, a forgotten container will fail in time and result in leakage of contents. Do not place any plastic lab ware in a flame. [7].

Evidence and Real Examples from Chemical Laboratories

The use of glass or plastic bottles to store chemicals, ignoring the controls of the specifications of the containers and sometimes occurs with the compatibility of the container does not comply with the cover, see figure 2 (picture A and B).

Picture A

Picture B

Figure2 (Picture A, and B). *Use of non-suitable bottles to conserve chemicals*

One of the most important observations worth mentioning is that the usage of some food containers (Figure 3, Picture A, and B) as chemicals containers. Here we would like to stress the fact that these food containers were not designed and made to be suitable for chemicals, so any storage of any chemical regardless its risk score may bring some risks to individuals within that laboratory.

Picture A **Picture B**

Figure3 (Picture A, and B). *Food containers used to preserve chemicals*

Chemicals vary in degree of risk. They need a full perception of all their potential risks and the adoption of necessary measures to deal with them safely must be done. Sodium azide is a dangerous substance in terms of fire and health hazards. The metal container has been highly corroded, leading to the risk of spillage in addition to the risk of toxic fumes that can be released from it when exposed to air humidity. Sodium azide has caused deaths for decades. [8] It is a severe poison. It may be fatal in contact with skin or if swallowed. [9]. In case of Ingestion: Highly Toxic! May cause breathlessness, pulmonary edema and rapid heartbeat within 5 minutes. Nausea, vomiting, headache, restlessness, and diarrhea may occur within 15 minutes. Other symptoms may include low blood pressure, abnormal breathing, reduced body temperature, reduced body pH, convulsions, collapse and death [10].See figure 4.The suitable container for sodium azide is the plastic container as shown in figure 5.

Figure4. *Sodium azide found in a metal box and has been corroded*

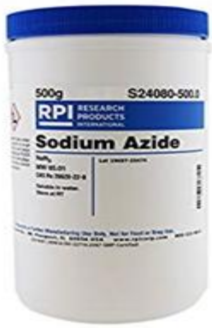

Figure5. *Sodium azide in suitable plastic container*

Another evidence for improper storage was spotted in the same laboratory is that some people stored bromine liquid in a poorly sealed bottle as seen in Figure 6. It is widely known within the chemistry community that bromine must be properly stored and carefully handled as it is extremely dangerous to the respiratory system of human beings and other creatures [11].

Figure6. *Non-sealed bromine bottles*

Likewise, it was spotted in the same laboratory that there was a broken bottle contains some hydrobromic acid (HBr) which is also as dangerous as bromine as shown in Figure 7, picture A, and B.

Picture A

Picture B

Figure7 (Picture A, and B). *Hudrobromic acid present in a broken neck glass bottle*

It is worth noting that we have reported and raised many similar safety issues in some research facilities in Iraq and suggested some feasible recommendations to offer a safer workplace environment [13-23].

Conclusion

In brief, we believe that the most convenient and safest way to store chemicals safely by keeping them in special chemical storage containers to ensure product compatibility with its container.

Hazardous chemical reactions can occur from improper storage when incompatible materials mix because of container failure in addition to monitoring the case of the container and stopper when storing for a long time must be taken in consideration.

Recommendations

- Chemicals must be stored safely by keeping them in special chemical storage containers to ensure product compatibility with its container.
- When the chemical is subdivided, the new container must be satisfying the original container specifications.
- Never use food containers to store chemicals.
- All damaged chemical containers or stoppers must be replaced with another according to original container specifications.
- We can refer to (MSDS) or (SDS) document to help us to find out the data related to the chemical.
- Storage of chemicals with some depending on the instructions for storage of chemicals according to the compatibility system.
- Training laboratory personnel on how to safely handle chemicals.
- Use specialized and trained personnel to get rid of damaged chemicals.

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