Product Safety

Dr. S.D. Deval
Manager-Development, Colour-Chem Limited.

Y2K has seen a fast changing scenario in the fields of science & technology. With the advent of computer era, the rate of these changes would be far more than our imaginations.Chemical industry also has witnessed a rapid growth in technology, with more and more number of chemicals being manufacturedcommercially.Acutthroat competition has resulted in advancement of technology; introduction of newer catalysts has simplified many "once upon a time difficult" reactions.

Another significant change seen in Y2K was the awareness of safety aspects in chemical industry. Today the environmental issues have compelled industry to respect the safety-related aspects more than anything else.

Chemical industry is obliged to focus on the following safety aspects: Product Safety, Process Safety and the Personnel Safety. Product safety essentially deals with the hazard due to the properties of substances. Process safety takes care of the hazards involved in various unit operations & processes such as filtrations, drying, milling, etc. The personnel safety aspects are concerned about protecting the people who are directly or indirectly exposed to the hazards due to products and/or processes.

This article aims at giving an overview about the product safety concept; the different types of hazards associated with chemical entities and the ways of communicating the hazards to the people handling them.

Safe & Unsafe Chemicals

The basic question that comes to our mind is that, "Which chemicals are hazardous and which are the safe ones?" And you will be surprised if the answer is "Practically every chemical is hazardous, including water!" Just imagine - you are carrying out a reaction like a Grignard reaction or lithiation reaction and water from condenser leaks into the reaction! Will you still dare to label water as a *safe chemical*? On the other hand, consider you have stored 100 gms of Sodium cyanide in a bottle. It will not cause any harm unless and until it finds entry into the human bio-system.It will stay for years together without causing a fire or any other problem.Is it not a *safe chemical*?

We have to reorient the ideas and concepts about safe and unsafe substances in our minds. Every chemical entity is born with its own physical and chemical properties and characteristics. Some of these properties may lead to dangerous situations and we have to avoid such situations. For example, water has a property of reacting with sodium metal. This reaction is exothermic and gives out hydrogen gas. Both the products of this reaction, namely heat and hydrogen, put together result in an explosion. When we know this property of water, we have to take care that water doesn't come in contact with sodium metal, accidentally. If we are carrying out the same reaction intentionally or by design, then we must be equipped to pacify the consequences.

Activities of Product Safety

Chemists should always bear in their mind that some of the properties of the substances being handled by them could be really dangerous. They have to be aware about these dangerous properties and ways to protect themselves, their equipment and the environment. Product safety, thus, is all about

(i) identifying the dangerous properties of the substances,
(ii) devising ways to protect man & machinery and the environment ,
(iii) communicating the data to the concerned.

The dangerous properties of substances are identified by subjecting them to various

tests. These tests are designed by experts and are disclosed in the form of guidelines, recommendations, laws, legislations, ordinances, etc. The performance of these tests and the interpretation of the tests results require expertise and experience. Hence, tests conducted by recognised laboratories with certified GLP are essentian for assurting correctness of the data. There are two main categories of dangerous properties of substances - physical/ chemical properties and toxicological/ ecotoxicological propertie. Following are some of the simple and preliminary tests that are carried out on solid substances for identifying their dangerous properties.

Some Preliminary Tests

Combustibility index : This test helps to determine whether an external source of ignition can propagate a fire in dust layer, and if so to what extent. In other words it tells about the behavior of the substance as faras fire hazard is concerned. Here a small strip of test substance is placed on ceramic plate and ignited at one end. The burning behavior is observed and rated on 1- 6 scale. (1-No ignition, 6-rapid flame propagation).

Auto ignition : This test is carried out in a special device called as Grewer Oven and is aimed to determine the temperature at which a substance ignites by itself in the presence of air and heat. Test sample and reference sample are gradually heated in stream of air. The point at which the sample temperature exceeds the reference is the Auto ignition temperature. Auto ignition temperature helps in deciding the drying temperatures.

Exothermic decomposition : The purpose is to determine the temperature at which a substance undergoes exothermic decomposition in the presence of heat - but in the absence of air (Oxygen). Test sample and reference sample are sealed in crucibles and heated in an oven. The point at which the sample temperature exceeds the reference is Exothermic Decomposition temperature. It is the usual behavior of many solid organic compounds to melt at a particular temperature (which is an endothermic even) and then decompose with evolution of heat. Exothermic decomposition temperature helps in deciding storage condition in warm places.

Dust explosibility : This test is done to determine whether the dust of a sample is explosive or not and is carried out in a special apparatus - Hartmann Apparatus. Here the test sample is deposited at the bottom of a glass vessel and dispersed with a blast of air. The dust/air mixture is ignited and observation is made. A dust is considered explosive if there is flame propagation after igniting the dust/air mixture, resulting in a pressure rise in a closed vessel. In order to determine the severity of dust explosion, some tests are done in 20 lit or 1000 lit vessels with various concentrations of dust and the rate of rise in pressure is plotted against the dust concentration.

Minimum ignition energy : It is the lowest value of energy, which is just sufficient to ignite a dust/air mixture of a substance at room temp and atmospheric pressure.

The test method is essentially the same as in the case of dust explosibility but it is connected with capacitors, which can give discrete amounts of energy.

After several trials with various concentrations of dust, the minimum energy, which will just cause ignition, is determined. This value helps in designing equipment for milling operations.

Following are some of the toxicological and ecotoxicological tests:

Acute oral toxicity : The purpose of this test is to determine whether a substance can cause toxicity (poisoning) if it is ingested. In this test the substance is suspended in groundnut oil and administered orally to a group of wistar rats and observed for 15 days. Any mortalities or toxicity signs are observed and recorded. The doses are increased in a stepwise manner and from the statistics of the results the dose (in terms of mg/kg of the body weight) at which half of the population is dead due to toxicity, is calculated. This is LD_{50} value of the substance (LD_{50}: Lethal Dose - 50% population). Substances, e.g. pigments, with LD_{50} values of more than 2000 mg/kg are generally considered safe for application.

Acute dermal irritation : This test helps to determine whether a substance can cause irritation in case it comes in contact with skin. The substance is moistened with groundnut oil and applied to the prepared area of the skin of a rabbit. Application is removed after 4 hr contact and the skin is observed for any signs of irritation (redness & swelling).

Acute eye irritation : The test is necessary to find out whether a substance can cause irritation to eyes if it comes in it's contact. Here the test substance is instilled into the conjunctival sac of an eye of a rabbit. Eye is washed after 24 hr contact and observed for any signs of irritation (redness, swelling, discharge and any effects on iris and cornea).

Acute aquatic toxicity : This is done to determine whether a substance can harm aquatic life if it contaminates water. Fish are exposed to water containing the substance at a particular concentration of test substance for a period of 96 hr. Any mortalities or toxicity signs are observed and recorded. As in the case of acute toxicity the LC_{50} values are of importance (LD_{50}: Lethal Dose - 50% population). Substances with LC_{50} values of more than 100 mg/lit are considered safe for pigments.

Ames test : Ames test is carried out to determine whether a substance is mutagenic or not. Mutagens are those substances which are capable of altering genetic material (genes, chromosomes) in a living cell. It is thought that many types of cancers have their origin in mutations taking place in a cell. The test is done with five strains of bacteria - *Salmonella typhium* at different concentrations of the substance and any alterations in the genetic material of the bacteria are detected.

Apart from these simple tests there are several other tests like oxidising properties, deflageration, flash points, sensitizing properties, teratology studies, neurotoxicity, biodegradability, Daphnia / Bacteria toxicity, terrestrial toxicity, etc, which may be necessary in order to assess the exact hazards associated with a substance. These studies could range from simple preliminary type to exhaustive tests involving many complicated procedures. Depending upon the nature of their products, different organisations specify the extent of the study needed in the form of a guideline for addressing the product safety issues as applicable to their products. These tests may be done on pure products (neat products, fine chemicals) as well on formulations or preparations (drugs, dyes, pigments, etc.). In general, performance of even simple preliminary tests is a very costly affair and runs in lakhs of rupees.

Once the product is thoroughly studied for its dangerous properties, it is very important to communicate the data to the user of the product. The user of the product could be plant personnel actually using the material, a quality control person who tests the material, a person from stores or even a transporter. All these users should be well aware of the properties of the product and ways to handle and store the same.

Material Safety Data Sheets (MSDS)

The communication of the safety related data to the above user is through Material Safety Data Sheets (MSDS) and through signs / labels[2]. It is now mandatory that any chemical substance being transported, small or large quantity, should be accompanied by its MSDS. Government of India has published a booklet on transportation of dangerous goods[3]. They have classified various substances depending on their hazardous properties, specified the precautions to be taken while transportation and what to do in case of an accident or fire. They also have prescribed the usage of various labels on the vehicles (You must have seen, especially on tankers something like " Hazchem - In case of fire, dial .....) which can easily convey the exact hazardous nature of the substances being transported. Similar labels are also seen on laboratory reagent bottles. Chemist are advised to make a habit of looking at these labels and undestanding the dangerous properties. It is also advisable to have a easily accessible file containing the MSDS of all the chemical substances used in the laboratory / plant.

Material safety data sheets are prepared in different styles and formats. However, the one recommended by the commission of the

European community, is elaborate and widely used. A typical MSDS contains the following 16 chapters: 1. Identification of the substance/ preparation and of the company / undertaking, so that in case of emergency the producer could be contacted: 2. Composition /information on ingredients; 3. Hazards identification 4. First-aid measures; 5. Fire-fighting measures; 6. Accidental release measures; 7. Handling and storage; 8. Exposure controls/personal protection; 9. Physical and Chemical properties; 10. Stability and reactivity; 11. Toxicological information; 12. Ecological information; 13. Disposal considerations; 14. Transport information; 15. Regulatory information; 16. Other information.

It is expected that any person involved in handling chemicals must read, understand and actas per the MSDS, so that many accidents could be avoided. Most of the accidents do not occur 'accidentally'; they are in fact just lapses in knowledge & appropriate precautions.

Conclusion

Every event is always accompanied by a package of its consequences. Modern life needs material to produce it's amenities and in turn is exposed to newer and newer hazards. Any lapses in taking appropriate precautions or lack of product safety knowledge could lead to disasters. It is the prime duty of a chemist to understand the dangerous properties of substances and play safe !

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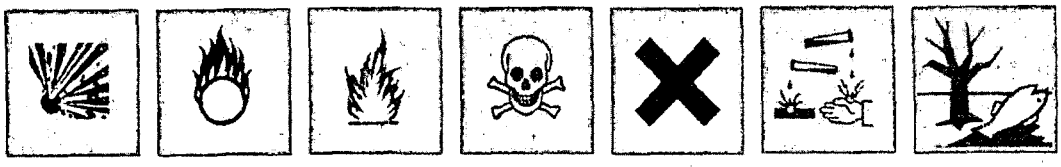
[1] *Safetety, hazard,* and *risk* are frequently used terms in product safely. Their exact meanings are as follows:

- **Safety** or loss prevention is a prevention of accidents by the use of appropriate technologies to identify the hazards of a chemical plant and to eliminate them.
- A **hazard** is anything with a potential for producing an accident.
- **Risk** is the probability of hazaeds resulting in an accident.

[2] Common labels seen on laboratory chemical bottles



[3] "A Guide to Safe Road Transport of Hazardous Chemicals", published by the Hazardous substance Management Division, Ministry of Environment & Forests, Government of India, New Delhi, Edn 1995

Dr. S. D. Deval Completed M.Sc. by research (1981) and Ph.D (1983) in Synthetic Organic Chemistry from Bombay University. He worked in Boots Pharmaceuticals Limited as Research Officer in their Basic Research Centre till 1992 (9 years) and then with Chemiequip Limited as R&D Manager till 1996 (4 years). Currently working at Colour Chem Limited, Thane, on basic research projects of Clariant G.m.b.H. on New Pigment Molecules as Manager- Development (5 years). He is a visiting faculty at Bandodkar College, Thane for their post graduate diploma course in Industrial Chemistry.