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ChemNote: Azides

Uses, Properties, Toxicity and Safety, Detection, Safe Decontamination and Destruction

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1. General Description

Azide compounds contain three nitrogen atoms connected to each other, $-N_3$, where the letter N denotes an atom of the element nitrogen. The subscript 3 signifies that three nitrogen atoms are bonded to each other. The free arm written as – denotes that the three nitrogen atoms of the azide are connected to one other atom.

We distinguish between organic azides and inorganic azides. In organic azides, the three nitrogen atoms are connected to a carbon atom and in inorganic azides they are connected to a metal such as sodium or lead.

1.1 Uses of Azides and Safety Considerations

Azides are encountered in several products including:

I. The gas-producing material in automobile air bags.
II. As chemical preservative in hospitals and laboratories, e. g. as preservative for vaccines.
III. As pest control material, mainly in agriculture.
IV. As ultra-labile, percussion-sensitive explosives, and,
V. As ingredients of certain drugs.

Heating azides, or mixtures which contain azides, results in a rapid decomposition of the material, and often in an explosion. This process releases a large volume of gases. This process is the basis of the use of azides in automobile airbag, where the gas released inflates the bags which prevent the impact of the head of travelers with the car interior parts during collision.

Azides are very toxic materials to viruses and to living cells, including cells of bacteria, fungi as well as mammalian cells. That is why they are used as preservation materials for vaccines and as poisons in pest control. Certain drugs, like the AIDS drug AZT, contain the azide group in their molecule.

Inorganic azides are not very stable compounds and often are very labile explosives. In particular, they tend to explode when a hard object impinges on them or scratch them. One such material is the well-known lead azide, $Pb(N_3)_2$. Because of the extreme sensitivity of these azides to impact, lead azide has been used as the percussion-sensitive primer at the end of the shell of cartridges. When the hammer of the gun impacts the primer at the casing end, the primer ignites and the propellant inside the bullet casing explodes A large volume of gas forms in the casing which propels the bullet to the target. The azides of copper, silver, mercury and, barium behave in a similar way.

While sodium azide is water soluble, most inorganic azides are not soluble in water. Most water streams contain some heavy metals such as copper, lead, mercury, iron nickel, etc. Consequently, **disposing of solutions containing sodium azide into water streams such as sewer water can result in the precipitation of insoluble azides such as lead azide.** Since these insoluble azides are explosive, great care should be exercised to prevent there precipitation and accumulation in sewer lines and sewer holes.

Acidic solutions decompose azides and form the volatile and extremely toxic and explosive hydrazoic acid, HN_3. This acid is volatile and will volatilize and form toxic gaseous mixtures. Acidifying solutions which contain azides should be done very carefully in well-ventilated areas.

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1.2 Modes of Absorption of Azides

Azides can be incorporated into the body by breathing vapors, droplets or dust containing azides, by skin contact-mainly with solutions or vapors, or by ingestion of solids, solutions or food containing azide.

Note: Wet skin absorbs all forms of azides faster than dry skin.

Since azides are not very stable, and may decompose on route into the body, the most dangerous mode of absorbing them is as vapors or droplets, mainly into the eyes or the skin. Ingesting azides interferes with all the biochemical processes which involve iron. It affects the neurological system and the heart.

1.3 Short and Long Term Toxicity and Safety Considerations

Azides present three types of hazards:

1. Formation of explosive materials and breathing or ingesting toxic materials formed in the explosion.
2. Immediate toxicity due to exposure to large doses of gaseous hydrazoic acid, droplets of solutions containing azide or particles of solid azides, and,
3. Chronic toxicity due to exposure to small doses of azide over a long period of time.

1.3.1 Danger Due to Explosions

Explosive decomposition of azides presents several types of danger including:

A. Danger due to the energetic nature of the explosion.
B. Breathing particles of azide that did not decompose, and,
C. Breathing hydrazoic acid vapors that were formed as a result of the decomposition.

The main explosive azides are lead, mercury, copper, silver and barium azides. These azides maybe encountered in bullets and in home-made explosives. Mixtures of azides, mainly sodium azide, with materials such as chlorine or fluorine-containing compounds, often polymers, are used in airbags and in other applications. Mixtures of sodium and/or of other azides, with powdered metals, mainly aluminum powder, are also explosive.

In common life, explosions due to azides may be encountered when:

I. Car airbags inflate due to an accident or due to malfunctions or heating of the azide mixture reservoir, and,
II. Firing of bullets due to unplanned heating or percussion of bullets casing.

Although some injuries have been recorded due to untimely and accidental explosions of air bags, on an overall balance, many more lives have been saved by airbags then hurt by azide explosions. No cases were reported of injuries or poisoning due to breathing azide vapors from the azide in airbags.

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1.3.2 Danger Due to Breathing or Ingestion of Relatively "Large" Doses of Azides

Exposure to "large" amounts of azide will produce short term toxicity and possible death due mainly to its effect on the transition metal ions in the body, predominantly the iron. Both di- and tri-valent iron form in the body iron oxide, FeO, as a result of the decomposition of their complexes with the azide ion. The iron oxide forms a colloid or a solid precipitate which cannot fulfill its biochemical functions. This effects most predominantly the capture and transport of oxygen from the lung to other body parts and thus results heart, breathing and nerve system physiological damage including possible death.

1.3.3 Danger Due to Breathing or Ingestion of Relatively "Small" Doses of Azides.

Repeated exposure to small doses of azides, i.e. chronic exposure to azides, results in damage to nucleic acids and to certain enzymes. Although these materials are normally replenished in the body relatively rapidly, the damaged molecules are highly undesirables. Exposure of females in the child-bearing age should be particularly prevented due to possible increase the probability of birth defects and mutations. This is much less important in the case of males in the child bearing age because of the rapid renewal rate of sperm cells.

1.4 Safety Considerations

1.4.1 In Daily Life

1. Avoid breathing gases formed after an air bag inflated in a car accident.
2. Do NOT manhandle or disassemble air bags or their inflation mechanism.

1.4.2 In Work Places

1. Avoid acidifying solutions or suspensions of azides, this will release very toxic gases including hydrazoic acid. If this has to be done, please do it in a fume hood.
2. Acidifying azide solutions with concentration smaller than 5000 ppm may be done **slowly** with constant stirring. If you have a choice of the acid, use dilute phosphoric acid.
3. AVOID poring azide-containing solutions to the drain; if it has to be done, neutralize the azide first. (**See below**). Explosive azide pockets may form, in the sewer and explode in an unpredictable manner or time.
4. Avoid contact between solutions containing azides or with solid azides and naked skin.
5. AVOID application of pressure or friction on solid azide, in particular dry solids.
6. AVOID application of strong impact or sudden pressure or friction on solid azide, in particular dry solids.
7. See the CDC procedure for decontamination of azide-containing plumbing (http://www.cdc.gov/niosh/78127_13.html). Although the CDC gives instructions for removing azides from sewer lines, it is highly undesirable to allow azides to accumulate. All azide-containing solutions should be neutralized prior to disposal.

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2. Detection

ChemSee offers two types of detectors for azides which can yield the results very rapidly:

I. Detectors for traces of azides, mainly for biological and pharmaceutical solutions. (Please see the AZD-N2 and AZD-P2 kits, Section 2.1).

II. Detectors for high and dangerous levels of azides in food and water. (Please see the KT-06 and KT-06R food poison detection kits, Section 2.2).

2.1 AZD-N2 & AZD-P2 Azide Detectors

The AZD-N2 and AZD-P2 are detection cards for biological and pharmaceutical material which detect azides at concentrations greater than 50ppm and 100ppm respectively. The AZD-N2 card detects azides in a neutral solution ranges pH 5-8. The AZD-P2 detects azides in basic solution ranges pH 8-14 and the kit includes a sample pretreatment pouch which safely brings the solution to an acidic range without the exposure to hydrazoic acid.

Figure 1 shows the detection of azides using ChemSee's Azide Detection Card. The card on the left shows an example of an azide detection card as it comes out of the packaging. The picture in the middle shows a negative sample while the one on the right shows a sample contaminated with Azides which forms a dark-grey band which is easily distinguishable.

The AZD-N2 and AZD-P2 are stable in ordinary storage conditions and have shelf life of at least 12 months. Never-the-less, it is recommended that they will be stored in a cool place.

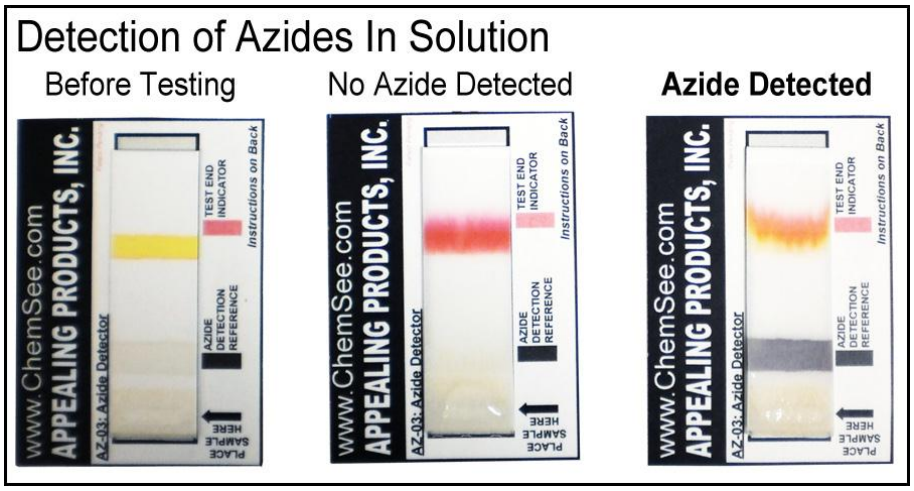

Figure 1: Detection of Azides in Solution

Ordinary materials do not interfere with the test for azides. No interference is known that could be present in alkaline solutions. However, if the solution tested is acidic with pH lower than about 4.5, excess of certain transition metals may interfere under a very narrow range of test conditions.

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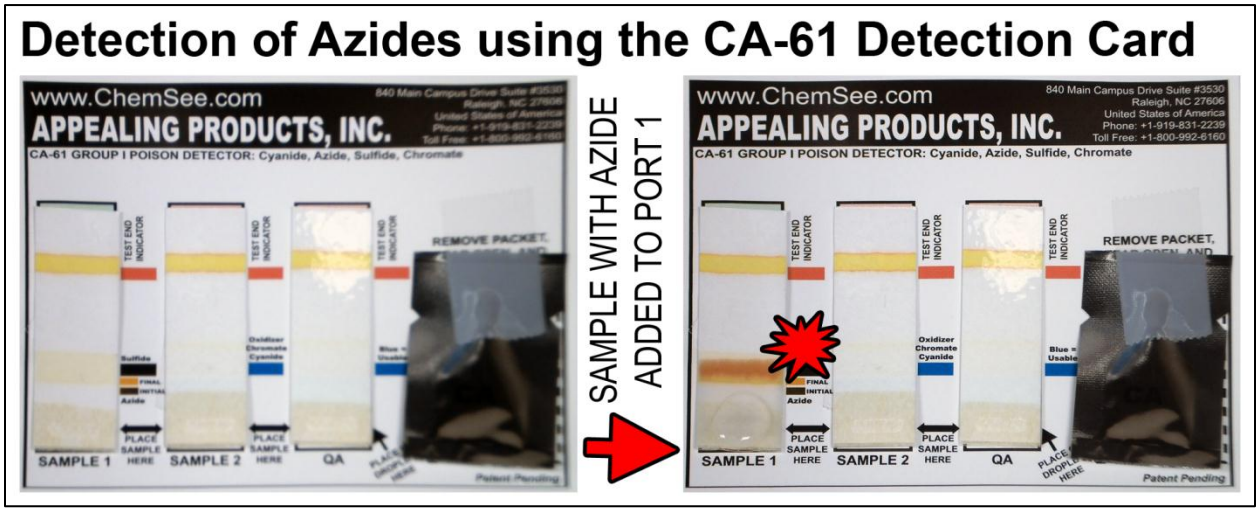
2.2 KT-06 and KT-06R Poison Detection Kits

ChemSee's KT-06 and KT-06R Food Poison Detection Kit offers comprehensive coverage for all common food poisons. This kit offers a portable way to detect food poisons including **azides in the field**. This is done by cutting the food sample into smaller pieces with the included utensils and placing them in the provided container. The container is then filled with the appropriate amount of water designated upon which type of food it is. With the provided eye dropper five drops are placed on the CA-61 Cyanides, **Azides,** Sulfides, and Chromates detection card. If a poisoned sample is present a band of color will form which can be identified using the color comparison reference.



3. Decontamination/Neutralization of Azide-Containing Solutions

ChemSee offers two kits for neutralization or decontamination of azide-containing solutions:

A. The AZD-NDEC kit for neutralization and decontamination of azide-containing solutions with pH lower than about 8.5, and,
B. The AZD-BDEC kits for neutralization and decontamination of azide-containing solutions with pH greater than about 8.5.

Azides-containing solutions, once properly neutralized using ChemSee kits, **may be disposed of in normal sewer. Make sure however that you follow the disposal of the waste solutions with plenty of water and no less than SEVEN volumes of water.**

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NOTE: Most modern sewer lines are properly vented. However, old sewer lines in places which were not designed to vent gases safely still exist. Disposal of waste solutions which contain materials such as formaldehyde, azide decontamination solutions, etc. should be done slowly while the waste solution is continually Please make sure the vent complies with ordinary safety regulations.

4. Decontamination and Neutralization of Solid Azides

Solid azides are very dangerous and may explode very readily. It is important to avoid:

1. Applying friction or hard instrument to scrap azide residue from container walls or corners of a container. (**Very dangerous** with azides of heavy metals).
2. Shaking vigorously containers with a powder of solid azides of heavy metals.
3. Mixing powdered azides with powders of metals such as aluminum, magnesium or zinc.
4. Mixing powdered azides with powders or films of halogen-containing polymers or liquids. Organic compounds containing chlorine, fluorine etc. including polymers, can form explosive mixtures with powders of azides.
5. Acidifying mixtures containing solid azides **should be done only if absolutely necessary.** Acidification should always be done in well-ventilated location and with as dilute acid as possible. Acidify the mixture in small batches at a time. If the acidification is not done in a hood, use a gas mask and protective suit.
6. The Center for Disease Control lists a procedure for decontamination/cleaning plumbing or sewer lines with azides (http://www.cdc.gov/niosh/78127_13.html). Again, the CDC gives instructions for removing azides from sewer lines but it is highly undesirable to allow azides to accumulate. Neutralize all azide-containing solutions prior to disposal.

Since each azide handling case is somewhat different ChemSee/Appealing Products customers may contact ChemSee or Appealing Products before trying to neutralize solid azides to discuss their special circumstances and thus minimize safety risks

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Table 1: Solubility of Common Azides

Name	Formula	Mol. Weight (g/mol)	Solubility (g/100mL @ 20°C)
Ammonium Azide	NH_4N_3	60.06	25.3
Barium Azide	$Ba(N_3)_2$	221.37	17.4
Calcium Azide	$Ca(N_3)_2$	124.12	45
Cesium Azide	CsN_3	174.93	22
Lead(II) Azide	$Pb(N_3)_2$	291.20	2.49E-02
Lithium Azide	LiN_3	48.96	67.2
Mercury(I) Azide	$Hg_2(N_3)_2$	485.06	2.73E-02
Potassium Azide	KN_3	81.12	50.8
Silver Azide	AgN_3	149.89	7.93E-04
Sodium Azide	NaN_3	65.01	40.8
Thallium(I) Azide	TlN_3	246.40	0.364

Table 2: Available Toxicity Data for Common Azides

Name	Formula	Toxicity (LD_{50})
Sodium Azide	NaN_3	27 mg/kg
Ammonium Azide	NH_4N_3	Very Toxic
Barium Azide	$Ba(N_3)_2$	Toxic

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