

## First Aid Procedures For Suspected Cyanide Exposure

### Introduction

Cyanide poisoning is a true emergency! The chemical, physical, and hazardous properties of some cyanide compounds are given on the following page. Cyanide is capable of inducing death in seconds to minutes following inhalation and intravenous injection, in minutes following ingestion of soluble salts, or minutes (hydrogen cyanide) to several hours (cyanogens) after skin absorption. Therefore, rapid aggressive therapy, emphasizing supportive care in combination with antidotes, is essential to increasing the chance of survival for a victim poisoned by cyanide.

### Mechanism of Action

Cyanide affects virtually all body tissue, attaching itself to ubiquitous metalloenzymes, rendering them inactive. Its principal toxicity is due to the inactivation of cytochrome oxidase (cytochrome aa3) and thus cellular respiration, even in the presence of adequate oxygen stores. Consequently, the most oxygen-dependent tissues, such as the brain, heart, and liver are most profoundly affected by acute cyanide poisoning.

### Antidotes

Time is critical in treating cyanide poisoning. The accepted treatment for cyanide poisoning is a three-step procedure. The first step involves the administration of amyl nitrite by lab personnel. Amyl nitrite is a volatile liquid that can be easily administered by inhalation. The remaining steps, administering sodium nitrite and sodium thiosulfate, must be conducted at the hospital.

Amyl nitrite and sodium nitrite transform (oxidize) a portion of one's blood (hemoglobin) to methemoglobin, which can then bind excess cyanide and remove it from the circulation. Usually, amyl nitrite inhalants are used to initiate the process, and then sodium nitrite is given intravenously to continue the process. As the blood concentration of free cyanide falls, it causes the dissociation of cyanide already bound to cytochrome oxidase. After administration of amyl nitrite and sodium nitrite, sodium thiosulfate is intravenously injected to permanently detoxify the cyanide. Thiosulfate provides a substrate for the enzyme rhodanese that catalyzes the conversion of cyanide to thiocyanate, which is nontoxic and readily excreted in urine.

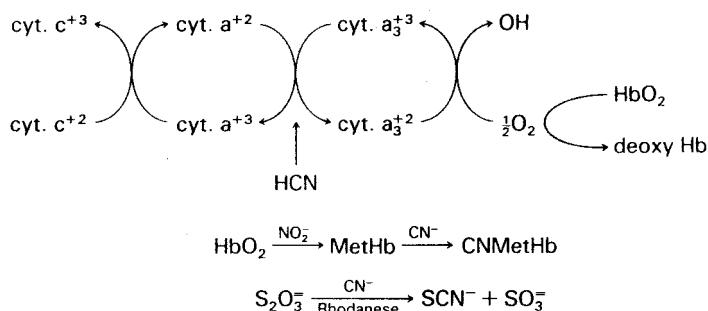


Figure 1. Cyanide Poisoning and Treatment

### Chemical, Physical, and Hazardous Properties of Some Cyanide Compounds

Compound	Hazardous Properties				Molecular Formula	Formula Weight	Melting Point (°Celsius)	Boiling Point (°Celsius)	Density	Solubility: gm/100 cc		Available Cyanide
	PEL* (mg/m <sup>3</sup> )	LD50* (mg/kg)	IDLH* (mg/kg)	NFPA* Health Rating						Cold Water	Hot Water	
Ammonium cyanide	5	...	25	...	NH <sub>4</sub> CN	44.06	Decomposes 36°	Sublimes 40°	1.02	Very Soluble	Decomposes	At 36°C decomposes to NH <sub>3</sub> and HCN
Calcium cyanide	11	39	55	3	Ca(CN) <sub>2</sub>	92.12	Decomposes over 350°	...	....	Decomposes	Decomposes	Forms Ca(OH) <sub>2</sub> and HCN in presence of H <sub>2</sub> O or humidity
Copper cyanide (I)	1	...	100	...	CuCN	89.56	473° (in N <sub>2</sub> )	Decomposes	2.92	Insoluble	Insoluble	K <sub>sp</sub> =3.2X10exp(-20)
Copper cyanide (II)	...	...	25 (mg/m <sup>3</sup> )	...	Cu(CN) <sub>2</sub>	115.58	Decomposes	...	...	Insoluble	...	Decomposes to CuCN on boiling or drying
Gold cyanide (III)	...	...	25 (mg/m <sup>3</sup> )	...	Au(CN) <sub>3</sub> · 3H <sub>2</sub> O	329.07	Decomposes 50°	...	...	Very soluble	Decomposes, Very soluble	...
Lead cyanide	11	...	55	...	Pb(CN) <sub>2</sub>	259.23	...	...	...	Slightly soluble	Soluble	...
Magnesium cyanide	...	...	100	3	Mg(CN) <sub>2</sub>	76.35	Decomposes 300° to MgCN <sub>2</sub>	Decomposes 600°	...	Soluble	Decomposes	...
Mercury (II) cyanide	...	...	10	3	Hg(CN) <sub>2</sub>	252.63	Decomposes	...	3.996	9.3	33	"Virtually non-ionized"
Potassium cyanide	5	5-22	25 (mg/m <sup>3</sup> )	4	KCN	65.12	...	...	1.52	50	100	Kh (25°C)=.0000254
Potassium cyanoaurate	...	...	25 (mg/m <sup>3</sup> )	...	K[Au(CN) <sub>2</sub> ]	288.1	...	...	3.45	14.3	200	Forms complex cyanides in aqueous solution
Silver cyanide	11	...	55	...	AgCN	133.84	Decomposes 320°	...	3.95	0.000023	...	K <sub>sp</sub> (20°C)=1.2X10exp(-16)
Sodium cyanide	5	5-300	25 (mg/m <sup>3</sup> )	3	NaCN	49.01	563.7°	1496°	...	48	82	Kh (25°C)=.0000251
Sodium cyanoaurate	...	...	25 (mg/m <sup>3</sup> )	...	Na[Au(CN) <sub>2</sub> ]	271.99	...	...	...	Soluble	...	Forms complex cyanides in aqueous solution
Zinc cyanide	11	54	55	3	Zn(CN) <sub>2</sub>	117.41	Decomposes 800°	...	1.852	0.0005	...	"Insoluble in water"
Hydrogen cyanide	10 ppm	40-71 ppm	50 ppm	4	HCN	27.03	-14°	25.6°	0.9	...	...	...
Iron cyanides for comparison:												
Potassium Ferricyanide	...	1600-2900	...	2	C <sub>6</sub> FeK <sub>3</sub> N <sub>6</sub>	329.26	...	...	1.723	460 g/L	...	...
Sodium Ferrocyanide	...	5100	...	2	Na <sup>4</sup> Fe(CN) <sub>6</sub> · 10H <sub>2</sub> O	321.92	...	...	...	Soluble	...	Decomposes at 435 C to NaCN, C, N, Fe

\* Notes: PEL = Permissible Exposure Limit without the use of personal protection in units of mg/m<sup>3</sup> of air or ppm.

LD50 = Lethal Concentration where 50% of test animals survive in units of mg/kg of body weight or ppm.

IDLH = Immediately Dangerous to Life and Health in units of mg/kg of body weight or ppm.

NFPA = National Fire Protection Association's established health hazard rating in units from 0 to 4 representing minimal, slight, moderate, serious, and severe hazards respectively.

Modified from: Criteria for a Recommended Standard: Occupational Exposure to Hydrogen Cyanide and Cyanide Salts, October 1976, DHHS (NIOSH) Publication No. 77-108.

By: Christopher E. Kohler, Certified Chemical Hygiene Officer



# INDIANA UNIVERSITY

## Laboratory Safety Guideline

### First Aid Procedures For Suspected Cyanide Exposure

#### Preparation Measures for Research Work Involving Cyanides

1. Maintain a current inventory of hazardous chemicals stored in the lab. Include all cyanide compounds used in the lab and maintain MSDS information.
2. Store cyanide compounds properly. Labs that use cyanide compounds and other hazardous chemicals should be locked when the lab is unattended.
3. Maintain a supply of amyl nitrite inhalants for emergencies. These inhalants are an antidote to cyanide poisoning. Ideally, a stock of inhalants should be available in the area where the cyanides are used. Immediate application of the antidote heightens the chances of the victim's survival. The use of the inhalants cannot cause permanent harm to the victim; therefore it is worth attempting this treatment even if there has been a slight delay in recognizing that the person has been poisoned.
4. Amyl nitrite is an attractive recreational drug, therefore strict security measures are required to control misuse. When not needed for potential first aid applications, the amyl nitrite must be locked inside a cabinet or drawer to limit access. Remove the amyl nitrite inhalants from the cabinet or drawer when working with cyanides and keep it within easy reach. Once finished working with cyanide, return the inhalants to the locked cabinet or drawer.
5. Plan your cyanide-requiring experiments carefully. Inform a co-worker in the lab area that you will be handling cyanide for a certain period of time and ask the co-worker to check in with you at given intervals.
6. Ensure that you and your co-worker have reviewed the first aid procedures and have received training on cyanide exposure procedures.
7. Work in a fume hood! Wear appropriate personal protective equipment! Call Environmental Health and Safety (855-6311) if you need your hood evaluated.

#### Suspected Exposure

##### *Assessing the Situation*

1. Hydrogen cyanide has a characteristic bitter, burning taste and a faint odor of almonds. You may detect a faint scent from the victim. Be aware, not everyone can smell cyanide (it is a genetically predetermined trait).
2. If cyanide exposure is known or suspected (whether ingestion, inhalation, skin absorption, or eye contact), you may notice the following symptoms:
  - general weakness
  - early giddiness, inebriation, and confusion
  - headache, vertigo, and dizziness
  - shortness of breath, which may be accompanied by chest pain
  - nausea and vomiting
  - generalized seizure activity and/or loss of consciousness
3. An early symptom is an initial increase in respiratory rate. Unless treated quickly, breathing becomes slow and gasping.
4. In a worst case scenario, exposure to a high concentration of cyanide will result in instantaneous collapse and cessation of breathing.



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## Laboratory Safety Guideline

### First Aid Procedures For Suspected Cyanide Exposure

#### ***Immediate Response***

1. **Contact University Police by dialing 911.** Request paramedic assistance. If possible, have a colleague make the call so you can help the victim as soon as possible.
2. If you can do so **without** endangering yourself, remove the victim from the lab to a safe area. Wear appropriate personal protective equipment to handle the victim who may be contaminated.
3. Evacuate the lab and close all the doors.
4. Administer the amyl nitrite inhalant once you and the victim are in a safe location.

**NOTE:** ALWAYS REMEMBER TO PROTECT YOURSELF FIRST AND FOREMOST. CALL FOR HELP RATHER THAN ENTERING A CONTAMINATED ZONE. DO NOT PUT EMERGENCY RESPONDERS IN THE POSITION OF HAVING TO SAVE YOU AND THE FIRST VICTIM!

#### ***Antidote Administration***

1. Break the amyl nitrite vaporole.
2. Hold it under the victim's nose for approximately 15 seconds.
3. Remove the vaporole and allow the victim to rest for 15 seconds.
4. Repeat steps 1 through 3 until the paramedics arrive or the amyl nitrite supply is exhausted, whichever comes first. Each vaporole should last about one minute or 3 to 4 whiffs.

**NOTE:** If the victim has suffered respiratory arrest or is seizing DO NOT administer the amyl nitrite vaporoles. Wait for the paramedics to arrive.

**NOTE:** Although some nitrile compounds can liberate hydrogen cyanide gas, which may cause inhalation exposure, most are absorption or ingestion hazards. Nitriles require conversion to cyanide before they produce symptoms. This metabolic conversion occurs in the GI tract and may take 12 hours or longer before toxicity becomes evident. If cyanide poisoning is suspected due to the absorption or ingestion of a nitrile compounds seek medical attention immediately before the onset of symptoms. Do not use the amyl nitrite inhalants unless immediately necessary.

#### **Post-Incident Restocking**

Once the emergency situation has been resolved, replace any used vaporoles. There should be a supply of 6 inhalants available at all times. The inhalants have a shelf-life of approximately 2 years (the expiration date must be printed on the outer container). Do not keep inhalants past their expiration date. Give expired inhalants to EH&S for disposal.



# INDIANA UNIVERSITY

## Laboratory Safety Guideline

### **First Aid Procedures For Suspected Cyanide Exposure**

#### **Procedures for Obtaining Amyl Nitrite Inhalants**

Lab personnel can obtain inhalants from the IU Health Center. Each Principal Investigator must complete an *Amyl Nitrite Authorization Form* (see attached) and send it to Cheryl Thomas (Pharmacy Director, IU Health Center). A copy of the authorization form must also be sent to the Lab Safety Specialist at the Department of Environmental Health and Safety, Creative Arts, Room 160. A *copy* should also be kept in the lab.

Once the Lab Safety Specialist has received a copy of the *Amyl Nitrite Authorization Form* they will ask you to complete a *Documentation Form* (attached). When the prescription is ready the IU Health Center will contact the Principal Investigator. The amyl nitrite inhalants can then be picked up at the IU Health Center Pharmacy between 8:00 a.m. to 4:30 p.m. Monday through Friday. Please remember to bring a copy of the authorization form to the pharmacy. The pharmacy will need to see this form before they will release the amyl nitrite.

**If you have any questions contact the Chemical Hygiene Officer:  
Environmental Health and Safety  
1514 E. Third Street  
Bloomington, IN 47405  
(812) 855-6311**



# INDIANA UNIVERSITY

## Laboratory Safety Guideline

### First Aid Procedures For Suspected Cyanide Exposure

#### Amyl Nitrite Authorization Form

Date: \_\_\_\_\_

Principal Investigator's/Supervisor's Name: \_\_\_\_\_

Department: \_\_\_\_\_ Building/Room #: \_\_\_\_\_

PI's Phone Number: \_\_\_\_\_ PI's E-mail Address: \_\_\_\_\_

Please provide a brief description of the research being performed and the anticipated use of the cyanide compounds.

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Number of Amyl Nitrite Inhalants Requested: \_\_\_\_\_  
(A supply of 12 inhalants should be available at all times)

Account Number to cover the cost: \_\_\_\_\_  
(Approximate cost \$6.99 per 12 inhalants)

Location where inhalants will be stored: \_\_\_\_\_  
(Department, Building, and Room Number)

**PI's Signature:** \_\_\_\_\_

Keep a **copy** for your files. **Send** a copy of the authorization form to the Chemical Hygiene Officer. The Chemical Hygiene Officer will obtain your order, deliver it to the lab, and record the appropriate information below:

Ampoule Expiration Date: \_\_\_\_\_ Ampoule Delivery Date: \_\_\_\_\_

Number of Expired Ampoules: \_\_\_\_\_ Date Received: \_\_\_\_\_

CN First-Aid Training Date: \_\_\_\_\_

