



Chemical Agents of Opportunity for Terrorism: TICs & TIMs

Module Four
Cyanide & Fumigants

Training Support Package

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Learning Objectives

- Indicate the sources and uses of cyanide and fumigants
- Describe therapies used to treat cyanide poisoning
- List the four most common fumigant gases
- Describe the clinical effects of exposure to these gases
- Explain how to treat victims exposed to these gases

Module Four – Cyanide & Fumigants

2

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Cyanide & Fumigants

- Cyanide
 - Salts (solids)
 - Gas
- Fumigant gases
 - Vikane (sulfuryl fluoride)
 - Methyl bromide
 - Phosphine

Module Four – Cyanide & Fumigants

3

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Cyanide

- Notoriety well deserved
- Historical relevance
 - Mass poisoning
- Pharmaceutical terrorism
- Weapon of Mass Destruction



Module Four – Cyanide & Fumigants

4

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Cyanide (CN): Properties

- Small molecule (26 Dalton)
- Boiling Point 27.7°C
- Colorless
- Bitter Almonds? Myth
- Water soluble



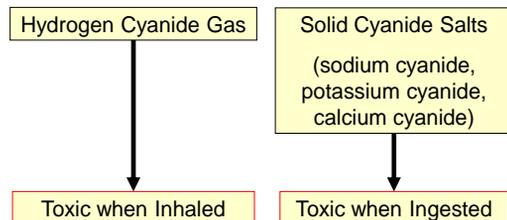
Sodium Cyanide

Module Four – Cyanide & Fumigants

5

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

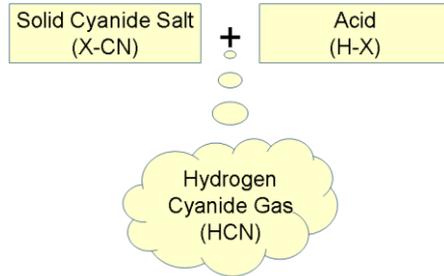
Cyanide: Two Common Forms



Module Four – Cyanide & Fumigants

6

Generating HCN Gas from Salts

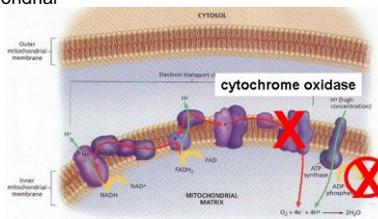


Cyanide

- Sources of cyanide (solid)
 - Industrial applications (electroplating, hardening steel, mining, fumigation,...)
 - Sodium, potassium and calcium cyanide are all readily purchased on the internet
- Other sources
 - Cyanogen chloride
 - Acetonitrile, acrylonitrile
 - Natural occurring cyanogens (laetrile)

Cyanide: Mechanism of Action

- Readily enters cells
- Inhibits mitochondrial respiration



Cyanide

Other Cytochrome Oxidase Inhibitors:

- Hydrogen sulfide
 - “sewer gas”
- Sodium azide
 - Component of airbags
- Carbon monoxide
 - minor mechanism

Cyanide: Toxic Quantities

- Cyanide salts
 - Lethal dose: 200-300 mg (3 mg/kg)
- Hydrogen Cyanide (HCN) gas
 - Lethal dose: 50-100 mg
 - 10 ppm for 2-hours = headache
 - 100-200 ppm = death in 1-hour
 - 200-300 ppm = death in several minutes

Cyanide: Clinical Manifestations

- “Gasp poison”
- Central Nervous System
 - Headache, confusion, agitation, syncope, convulsions, coma, death
- Cardiovascular
 - Tachycardia, hypertension
 - Bradycardia, hypotension
 - Cardiac arrest
- GI
 - nausea, vomiting, abdominal pain



Knock-Down Gases

Some possible suspects:

- Hydrogen cyanide
- Hydrogen sulfide
- Carbon monoxide
- Oxygen-deficient air



Cyanide: Onset of Symptoms

Time to Onset of Symptoms

- Cyanide salt and cyanide gas (HCN)
 - Minutes
 - Inhalation of gas >> ingestion >> dermal
 - Survival > 10 minutes, most likely will survive
 - All or Nothing
- Aliphatic cyanogens & Natural cyanogens
 - Hours – must be metabolized



Cyanide: Diagnostic Testing

- ABG
 - Anion gap metabolic acidosis
- VBG
 - “Arteriolization” of venous blood gas
- Lactate
 - Elevated
- Blood cyanide levels
 - Whole blood or serum
 - 2-3 day turn around time



Cyanide: Real World Scenarios

- Battlefield
- Mass Murder
- Mass Suicide
- Homicide
- Pharmaceutical Terrorism
- Environmental Terrorism
- Economic Terrorism



Cyanide: Battlefield

- WMD
 - Researched as a weapon in WW I
 - Used in concentration camps in WW II and in caves (Adjimushkaiskiye)
 - Zyklon B



Cyanide: Mass Murder

- Nazi Death Camps
 - Millions of Jews, gypsies, and others died in CN gas chambers
 - Gas chambers disguised as communal showers
 - Some suffering more than 20 min before death



Chemical Agents of Opportunity for Terrorism:
TICs & TIMs



Execution by Cyanide Gas Chamber

- CN salts dropped into sulfuric acid → HCN
- Few states now use it
- 1930 to 1980 (11 states):
 - 945 men
 - 7 women
- 1960 Caryl Chessman told reporters he would nod his head if it hurt. He nodded his head for several minutes before he died.



Module Four – Cyanide & Fumigants

19

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs



Cyanide: Other Sources

The most common source of cyanide exposure is incomplete combustion of:

- Wood
- Plastic
- Rubber
- Polyurethane
- Wool
- Silk



Module Four – Cyanide & Fumigants

20

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs



Cyanide: Incomplete Combustion

Happy Land Social Club Fire Bronx 1990: 87 deaths



Module Four – Cyanide & Fumigants

21

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs



Cyanide: Incomplete Combustion

The Station Nightclub Fire Providence 2003: 100 deaths



Module Four – Cyanide & Fumigants

22

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs



Cyanide: Homicide

Teen charged with poisoning friend

Friday, January 10, 2003 Posted: 1:59 PM EST (1055 GMT)

ELLCOTT CITY, Maryland (AP) – A teenager was charged Thursday with first-degree murder for allegedly killing a romantic rival by spiking his soda with cyanide.

Police said Ryan Furlough, 18, laced his friend's drink with the poison as they played video games in Furlough's basement in Ellicott City in suburban Baltimore.

Benjamin Vassiliev, 17, went into respiratory arrest last Friday after drinking the soda and died Wednesday.



Police say Ryan Furlough, left, laced Benjamin Vassiliev's drink with cyanide.

Module Four – Cyanide & Fumigants

23

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs



Cyanide: Homicide

Timeline:

- 17 yr old male drinks KCN spiked soda
- Feels unwell and goes to the bathroom
- Emerges from the bathroom and collapses
- EMS intubate for apnea. Vital signs present.
- Cardiac arrest in hospital. ACLS and recovery.
- Transfer to tertiary care center.
- Dx made. Steps 2 & 3 of antidote kit administered.
- No neurologic recovery.

Module Four – Cyanide & Fumigants

24



Cyanide: Suicide

- 55 yr old male ingests KCN tablets at sentencing hearing.
- Subject tells lawyer who tells judge
- In minutes: lethargy > collapse > shock
- No antidote kit at scene
- Subject received antidote kit at hospital (~15 min post-ingestion)
- No neurological recovery.



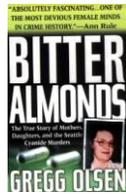
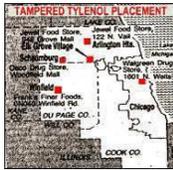
Cyanide: Mass Murder

- The Jonestown Massacre
- Jonestown, Guyana (1978)
 - CN-laced Kool-Aid
 - 913 Deaths



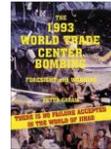
Cyanide: Drug Tampering

- Pharmaceutical Terrorism
 - 1982 – Acetaminophen
 - 1991 – Pseudoephedrine



Cyanide: Terrorism

- Appearance at incidents:
- NY WTC (1993)
 - Ingredients for HCN in the truck
 - Tokyo Subway (1995)
 - Sarin
 - Ingredients for HCN in bathroom



Cyanide: Environmental Terrorism?

- Cyanide spill into Tisza River, Romania (2000)
- 100,000 cubic meters of cyanide containing water released when a gold mine dam overflowed
- All river life killed for miles downriver



Cyanide: Economic Terrorism

- Hoax - 1989
- Chilean Grapes Imported into the US Alleged to Contain Cyanide





Cyanide: Missing Cyanide (2004)

- 15-gallon drum of sodium cyanide was lost from a delivery truck
- Located after 1-week search in N. Dakota
 - Was being hauled for delivery to beekeepers
 - Used to fumigate and kill excess bees
 - Not legally registered for this use
- Became a multi-state investigation

GrandForksHerald.com

Posted on Sat, Nov. 13, 2004

Sodium cyanide probe extends beyond North Dakota

By A.J. MICHAELSON
Associated Press

ISMARCK, N.D. - A drum of sodium cyanide found in northeastern North Dakota after more than a week of searching has sparked a larger probe stretching from coast to coast.

Environmental Protection Agency regional offices in Denver, Chicago, Atlanta and Kansas City, Kan., are coordinating an investigation into how widespread the illegal use of the potentially deadly chemical is among beekeepers, said Tim Osag, an EPA enforcement coordinator in Denver.



Cyanide: Treatment

Prehospital Care

- Safely remove victims from source
- Restore or maintain airway patency
- Maximize oxygenation
 - 100% NRBM or BVM
- Cardiopulmonary support to maintain VS
 - IVF and/or dopamine, norepinephrine
- Decontamination



Cyanide Antidote Kit (CAK)

- 3-steps
 - Amyl nitrite
 - Sodium nitrite
 - Sodium thiosulfate
- Converts cyanide to thiocyanate
- One kit treats two people



Cyanide: CAK

CAK Dosing

- Amyl nitrite - inhale if no IV access yet
- Sodium nitrite (3% solution)
 - Adults → 300 mg (10 ml) IV over 15-20 min
 - Peds → Hgb based
- Sodium thiosulfate (50 ml 25% solution)
 - Adults → 12.5 g (50 ml) IV
 - Peds → 1.65 ml/kg IV
- May repeat if large cyanide exposure



Cyanide: CAK

- Effective
- Safe
- Side Effects
 - Nitrite
 - Hypotension
 - MetHb
 - Sodium Thiosulfate
 - vomiting



Cyanide: Cyanokit™

Cyanokit

- Hydroxocobalamin
- Converts cyanide to cyanocobalamin (vitamin B12)

Dosing

- 5g IV
- 10g IV in cardiac arrest





Cyanide: Treatment

Treatment: Cyanokit

- Effective
- Safe
- Adverse Effects
 - Red urine
 - Red skin
 - Interferes with cooximetry measurements because of its intense red color



Cyanide as a Weapon

An Ideal Terrorist Weapon

- Plentiful
- Readily available
- Special knowledge not required
- Capable of causing mass casualties
- Capable of causing social disruption
- Requires large quantities of resources to combat its effects



Any terrorist attack that involves explosions or fire will likely result in HCN release



Fumigant Gases

- Sulfuryl fluoride (Vikane 7)
- Methyl bromide
- Phosphine



Fumigants

Applications

- Insect or rodent control in grain storage
- Insect or rodent control in structures
- Eradication of soil pests in farming



Fumigant Gases

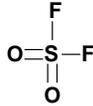
- Like HCN, could be introduced into a closed space through ventilation system or other conduits



Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Sulfuryl Fluoride

- Used in 85% of building fumigations
- Colorless
- Odorless
- Irritating
- 3.5 times heavier than air
- Exposure to fatal concentrations possible without warning odor
- No re-entry until air levels < 5 ppm



Module Four – Cyanide & Fumigants

43

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Sulfuryl Fluoride

- Clinical Manifestations
 - High concentrations
 - Seizures
 - Syncope / dysrhythmias
 - Respiratory arrest
 - Lower concentrations:
 - Vomiting
 - Diarrhea
 - Salivation
 - Lung injury



Module Four – Cyanide & Fumigants

44

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Sulfuryl Fluoride: Treatment

Management

- Removal from source of exposure
- Ventilation
- Oxygen
- Monitor for hypocalcemia
 - ECG (prolonged QTc)
 - Serum or ionized Ca²⁺
- Administer calcium as needed

Module Four – Cyanide & Fumigants

45

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Sulfuryl Fluoride

- Elderly couple reenter fumigated home before Vikane had fallen to a safe levels:
 - Husband:
 - Shortness of breath, seizures
 - Death 48 hrs after reentry
 - Wife:
 - Weakness, nausea, vomiting
 - Death 72 hrs after reentry (lung damage)

Module Four – Cyanide & Fumigants

46

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Methyl Bromide

- Odorless, colorless gas
- Chloropicrin (lachrymator) added as warning agent
- MeBr heavier than air
- Broad spectrum of activity
 - Alkylating agent
- Penetrates rubber and neoprene
- Being phased out due to environmental concerns



Module Four – Cyanide & Fumigants

47

Chemical Agents of Opportunity for Terrorism:
TICs & TIMs

Methyl Bromide: Clinical Signs

- Acute high-level exposure → rapid onset of sx's
 - CNS depression, delirium, seizures, pulmonary edema
 - Skin injury, burns, blistering reported with high-level dermal exposure
- Lower level exposure
 - Delayed onset toxicity well-documented
 - Mucosal irritation
 - Headache, dizziness, Nausea, vomiting
 - Progression (hours) to visual symptoms, ataxia, tremor, delirium, seizures
- Sxs reversible with mild intoxication
 - Permanent effects have been reported in severe cases

Module Four – Cyanide & Fumigants

48



Methyl Bromide: Case Study

- Adult female occupying a guest house rapidly developed headache, flu-like symptoms
- Within 24 hours, found in status epilepticus
- Initial labs remarkable for severe liver, kidney injury
- Expired 19 days post-exposure
- A building next door had undergone fumigation with methyl bromide. Seven 1-2 inch underground conduits connected the buildings.
- Methyl bromide had traveled from the adjacent building into the cottage.

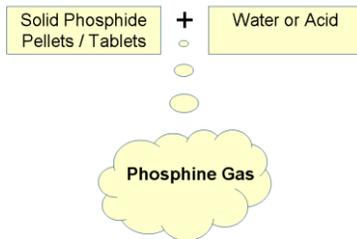


Phosphine (PH₃)

- Forms
 - Gas (vapor density 1.17)
 - Aluminum and Zinc phosphide pellets
- Smells like garlic and rotten fish
- Many uses in agriculture & structural pest control
- Used in semiconductor industry
- Concentration effects
 - 400-600 ppm - severe toxicity in 30 min
 - 1000 ppm - immediate death



Generating Phosphine Gas



Phosphine: Treatment

Clinical

- Early/mild cases
 - Non-specific
 - GI effect, cough, chest tightness, eye irritation
- Late/serious exposure
 - Pulmonary edema, coma, seizures, death
 - Knock-down gas
 - Rapid progression and deterioration in fatal cases



Phosphine: Case Study

- 5-year-old girl suddenly develops difficulty breathing at home
- Has a cardiac arrest - Unable to resuscitate
- Family members were ill as well
 - Developed acutely after a period of heavy rainfall
 - Odor noted in basement
- Investigation: a cupful of aluminum phosphide pellets had been placed in a hole adjacent to the basement foundation
- Child's father was a professional exterminator



Phosphine

Inhalation of phosphine from illicit Methamphetamine production labs:

- Willers-Russo (1998)
 - 3 victims found dead in motel room
 - First responders noted significant chemical odor
 - Phosphine gas levels far greater than 0.3 ppm (TLV)
- Burgess (2001)
 - Acute symptomatic inhalation exposure in first-responder (law enforcement)
 - 2.7 ppm for 20-30 minutes
 - Persistent, objective signs of obstructive pulmonary impairment weeks after initial exposure



Treating Fumigant Poisoning

- No antidotes available
- Remove victim from source
- Thorough decontamination
- Oxygenation
- Symptomatic and supportive care as indicated



Fumigants: Summary

Gas	Properties	Clinical manifestations	Management
Vikane	Poorly detectable (occasionally mixed with chloropicrin)	Neurologic Gastrointestinal	Remove from exposure Flush skin/eyes 100% O ₂ Supportive care
Methyl Bromide	Poorly detectable (occasionally mixed with chloropicrin)	Potentially delayed onset Mucous membranes irritation Neurologic Seizures ☹️ Lung	Same
Phosphine	Fishy / garlic odor	Neurologic, Cardiac, Lung	Same



Summary

- Forced air ventilation systems could be used by terrorists to disperse toxic gases or aerosols.
- Cyanide gas and fumigants are easily obtained and well-suited for airborne dispersal.
- Cyanide gas exposure should be treated with oxygenation, supportive care, and antidotal therapy.
- No antidote is available for the fumigants discussed in this module. Treatment should focus on decontamination and supportive therapy.



Questions?