



Blood Agents and their Countermeasures

$N\equiv C-H$	$N\equiv C-C\equiv N$	$N\equiv C^{-+}Na$	$N\equiv C-Br$
Hydrogen Cyanide	Cyanogen	Sodium Cyanide	Cyanogen Bromide
LD ₅₀ *	LD ₅₀ *	LD ₅₀ *	LD ₅₀ *
Inhalation 300 mg/kg	Inhalation 350 mg/kg	Ingestion 64 mg/kg	Inhalation 39 -52 mg/kg
Ingestion 50 - 200 mg/kg	Skin 10 - 15 mg/kg	Skin 77 mg/kg	Ingestion 25-50 mg/kg
Skin 100 mg/kg			Skin 250-1000 mg/kg

* LD₅₀: Median lethal dose in humans extrapolated from animals, toxicological profile of Cyanide, Agency for Toxic Substances and Disease Registry, U.S. Department of Health & Human Services.

Effect

Cyanide ion (CN⁻)
Produced by blood agents



Inhalation



Ingestion



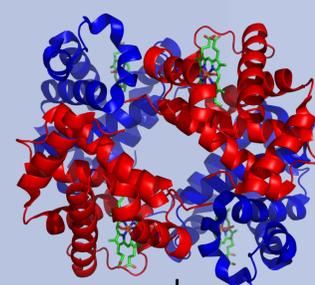
Skin
(Adsorption)



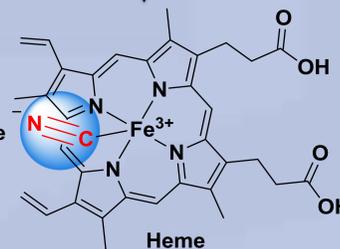
Red Blood Cells



Hemoglobin



Heme-Cyanide Complex



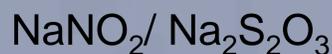
- Cyanide ion (CN⁻) binds to hemoglobin, the oxygen-carrying molecule in red blood cells.
- It distributes throughout the body via the bloodstream where it binds to the metabolic enzyme cytochrome c oxidase. This prevents cells from using oxygen and producing energy.
- Symptoms of hydrogen cyanide poisoning:
 - Headache, nausea, dizziness (mild doses)
 - Convulsions and coma (high doses)
 - Respiratory and cardiac arrest (very high doses)

Countermeasures including supportive measures

Structure

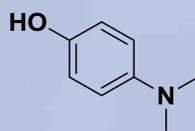
Effect

Sodium nitrite/ Sodium Thiosulfate
(administered intravenously)



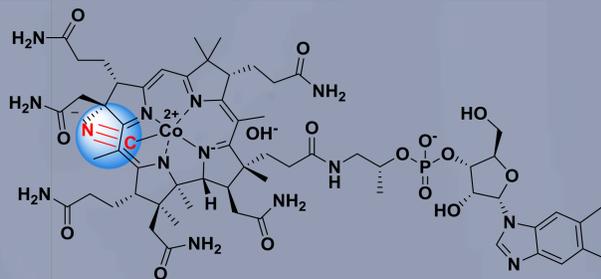
Nitrite oxidizes iron from the ferrous (+2) state to the ferric (+3) state, increasing the concentration of circulating ferric ion which competes for cyanide binding to the ferric ion of cytochrome c oxidase. Sodium thiosulfate binds to cyanide to produce thiocyanate, which is less toxic and eliminated via the kidneys.

4-Dimethylaminophenol (4-DMAP)
(administered intravenously)



Oxidizes iron from ferrous (+2) to ferric (+3) at a faster rate than sodium nitrite.

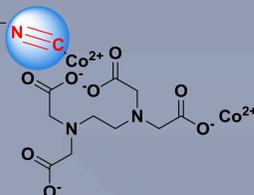
Hydroxocobalamin
(a form of Vitamin B₁₂, administered intravenously)



Binds to cyanide to form a complex that can be cleared from the body via the kidneys.

Dicobalt EDTA

Caution: High incidents of side effects have been observed in patients receiving this treatment.



Nitrocobinamide

NO₂-vitamin B₁₂

Reverses cyanide inhibition of the enzyme cytochrome c oxidase.

Hyperbaric Oxygen Therapy

Potentiates activity of other counter-measures by displacing CN⁻ from heme.

