



# Cyanide destruction: A New Look at an Age Old Problem

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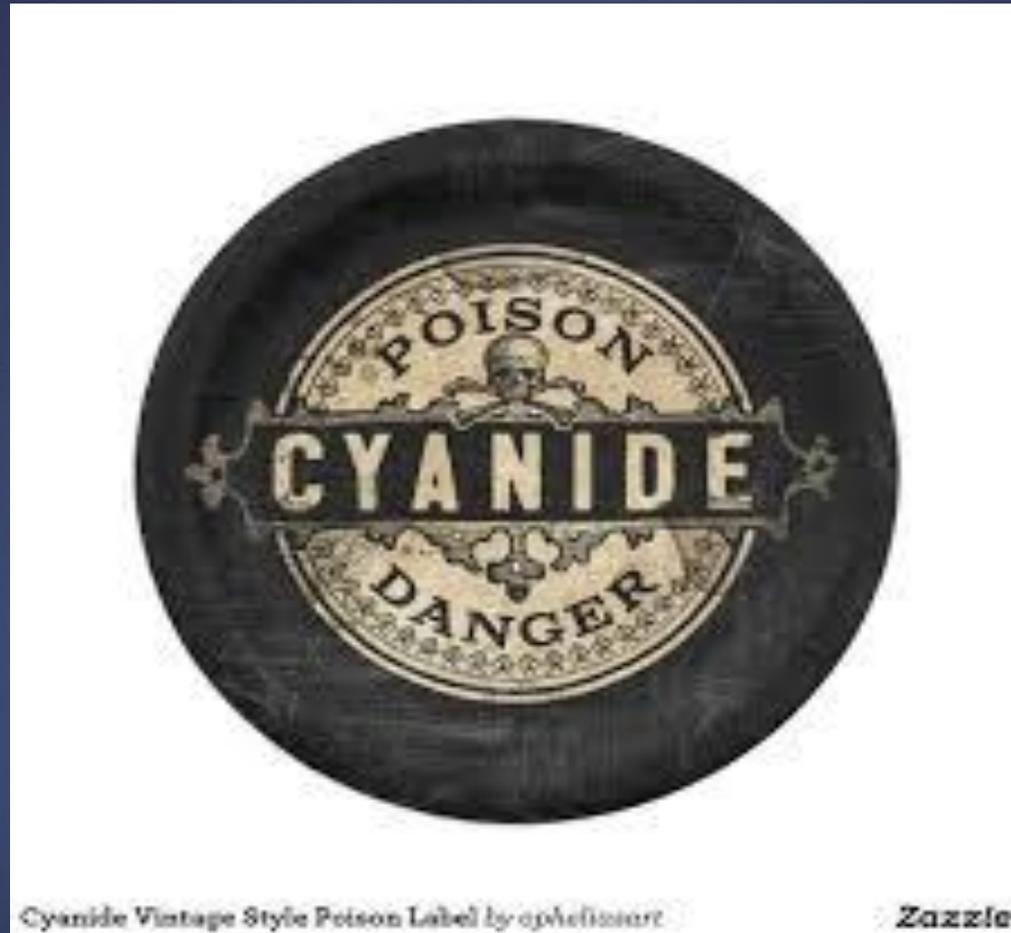
# Cyanide, what is it good for



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But, it kills you, right?



Cyanide Vintage Style Poison Label by opheliasart

Zazzle

# Cyanide destruction, more than one way to kill the rat

- ▶ Alkaline chlorination
  - ▶ Biological treatment
  - ▶ Caro's Acid
  - ▶ Hydrogen peroxide
  - ▶ Sulfur dioxide and air
-

# Alkaline chlorination

- ▶ 2-step process
  - ▶ Sodium hypochlorite usage is high
  - ▶ First step produces cyanogen chloride
  - ▶ Second step hydrolysis of cyanate to ammonia and carbonate
  - ▶ May need a de-chlorination step
-



# Chemical reactions

- ▶ Forming Cyanogen Chloride in the first step:



- ▶ Cyanogen Chloride Hydrolyses to yield Cyanate:



- ▶ Hydrolyses of Cyanate to form Ammonia and Carbonate, second step:



# Bacteria are amazing

- ▶ Aerobic biological process use Pseudomonas, Alcaligenes, Achromobacter and others to form cyanate
  - ▶ Cyanate is converted to ammonia and bicarbonate
  - ▶ Thiocyanate is converted to ammonia, sulphate and bicarbonate
  - ▶ Denitrification takes place
-

# Chemical reactions

▶ Oxidation in aerobic biological treatment:



▶ Cyanate biologically converted to ammonia and bicarbonate:



# Caro's acid: not for pancakes

- ▶ Introduced in early 1990's
  - ▶ Hydrogen peroxide and sulphuric acid in an exothermic reaction
  - ▶ Very unstable, needs to be used immediately
  - ▶ Rapid reaction process
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## Chemical reactions

- ▶ Rapid process, complete within a few minutes
- ▶  $\text{H}_2\text{SO}_5 + \text{CN}^- \rightarrow \text{OCN}^- + \text{SO}_4^{-2} + 2\text{H}^+$
- ▶ 1:1 mole ratio for oxidation of cyanide to cyanate

# Hydrogen peroxide

- ▶ Widely used at steel hardening facilities
  - ▶ Must have a catalyst such as copper present
  - ▶ Metals bound by cyanide must be precipitated as a metal hydroxide
-

# Chemical reactions

- ▶  $\text{CN}^- + \text{H}_2\text{O}_2 \rightarrow \text{OCN}^- + \text{H}_2\text{O}$
- ▶  $\text{M}(\text{CN})_4^{2-} + 4\text{H}_2\text{O}_2 + 2\text{OH}^- \rightarrow 4\text{OCN}^- + 4\text{H}_2\text{O} + \text{M}(\text{OH})_2$   
(SOLID)
- ▶ Soluble copper catalyst used to increase reaction rates

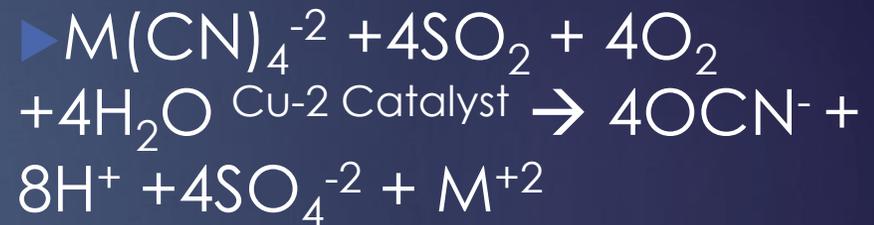


# Sulfur dioxide and air

- ▶ 2 patented versions of process, Inco and Noranda
  - ▶ Mining operations use process to treat tailing slurries
  - ▶ Effective for treatment of free and WAD cyanides
  - ▶ Catalysts are needed
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## Chemical reactions

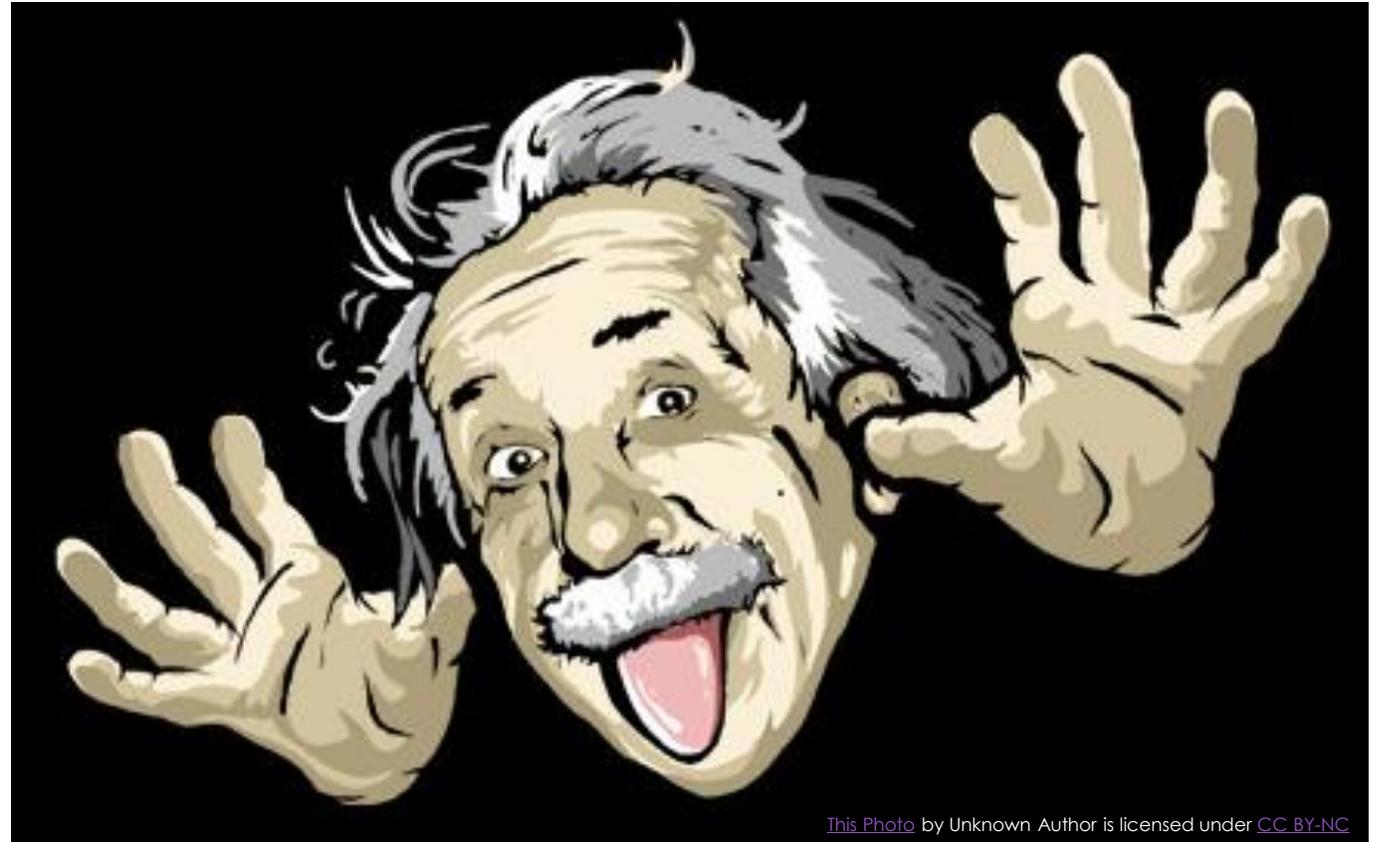


▶ pH of 8-9 optimal

▶  $\text{SO}_2$  can be liquid sodium dioxide, sodium sulphate, or sodium metabisulfite

# New technologies

- ▶ Stabilized Caro's Acid
- ▶ Electrolysis
- ▶ Ion exchange





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