



Highly Reactive and Explosive Materials

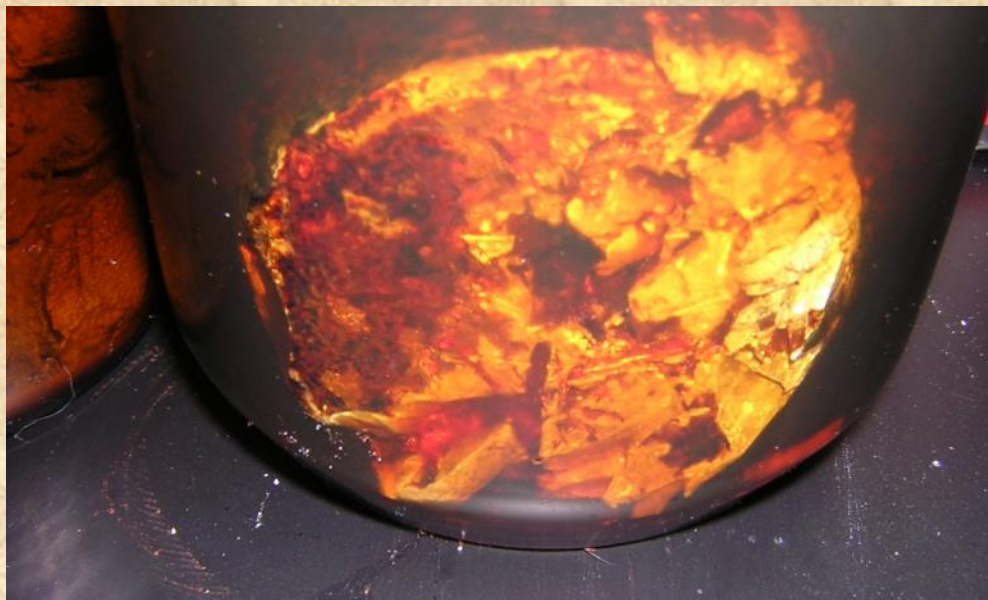
Dave Waddell

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waddellenviro@yahoo.com

Part One:

Highly Reactive and Unstable Chemicals



Goal 1. Keep you out of trouble



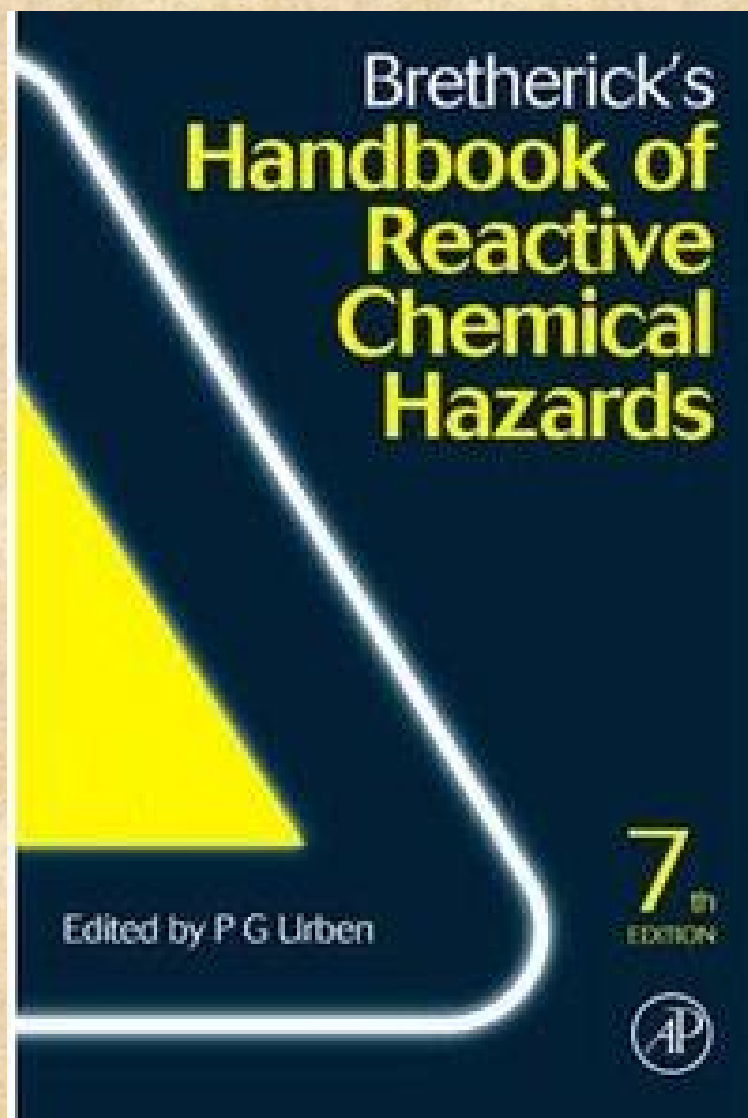
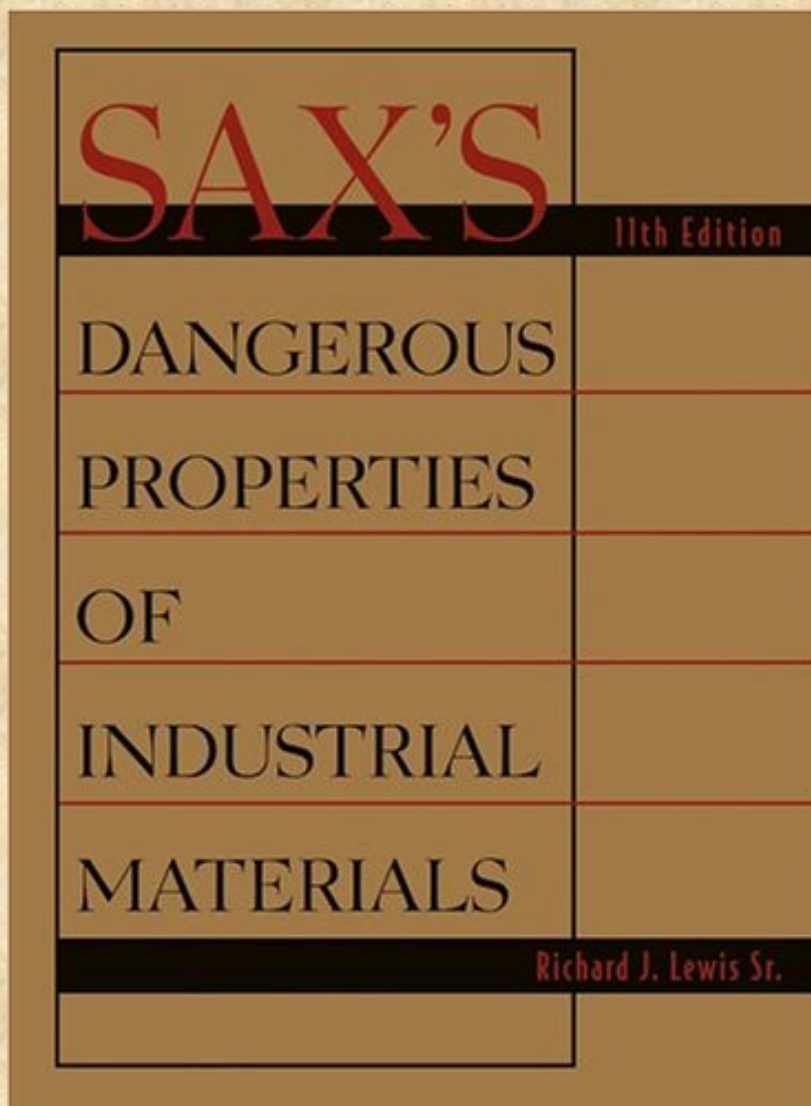
Goal 2. Keep you awake



Goal 3. Keep it light (bomb squad humor)



Handbooks of Reactive Chemicals



University Websites - Great Resources



ENVIRONMENTAL PROTECTION

University Safety and Assurances



Safety & Health

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Reactive Chemicals

Laboratory workers must be trained to recognize those chemicals which they may come across which are potentially reactive or explosive. Reactive chemicals, for the purpose of this page, are defined as those substances which can, in contact with air, water or other common substances, vigorously or violently give off heat, energy or toxic gases or vapors. Some of the classes of chemicals which can contain reactive chemicals include:

Reactive Chemicals

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- [Air Reactive Chemicals-Pyrophoric](#)
- Blasting Agents
- Cyanide containing compounds
- [Explosives](#)
- Fuming Acids
- Heat Sensitive
- Organic Peroxides
- [Peroxide Formers](#)
- [Polymerizing Chemicals](#)
- Pyrotechnics
- Shock Sensitive
- Spontaneously combustible
- [Water Reactive Chemicals](#)



Household Hazards Line Gets a Call



- My father died.
- Found old chemicals in the basement
- Can I drive them to the HHW site?

HHW Staff Asked for a List

- Two chemicals stood out
 - Ethyl Ether
 - Picric Acid
- Don't come to us, we'll visit you!

First Impression





- Crystals

- Corks

- Residue on shelf

- Tripping hazards



COCHINEAL

POISON

POTASSIUM
FERROCYANIDE
 $K_4Fe(CN)_6$

AMMONIUM
OXALATE
 $(NH_4)_2C_2O_4$

Red
Phosphorus

LEAD
NITRATE
 $Pb(NO_3)_2$

FERRIC
AMMONIUM
CITRATE

The world's
most sought-
after hair-
auty





quantities lost, you get regular

ANTHRACENE
36

SODIUM
PERMANGANATE
4 OZ.
Frank Drug Co.
Pittsburgh, Pa.

ALUMINUM
HYDROXIDE

20.500
PHEAT

ROYAL
STANDARD



- Gilbert Chemistry Kit
- “Not for children who can’t read”
- Copyright 1936
- 75 chemical containers

June 8, 1949 paper under bottles



Potential Explosives



Located 8 blocks from Dave's office



An interlude with “Dr. Boom”

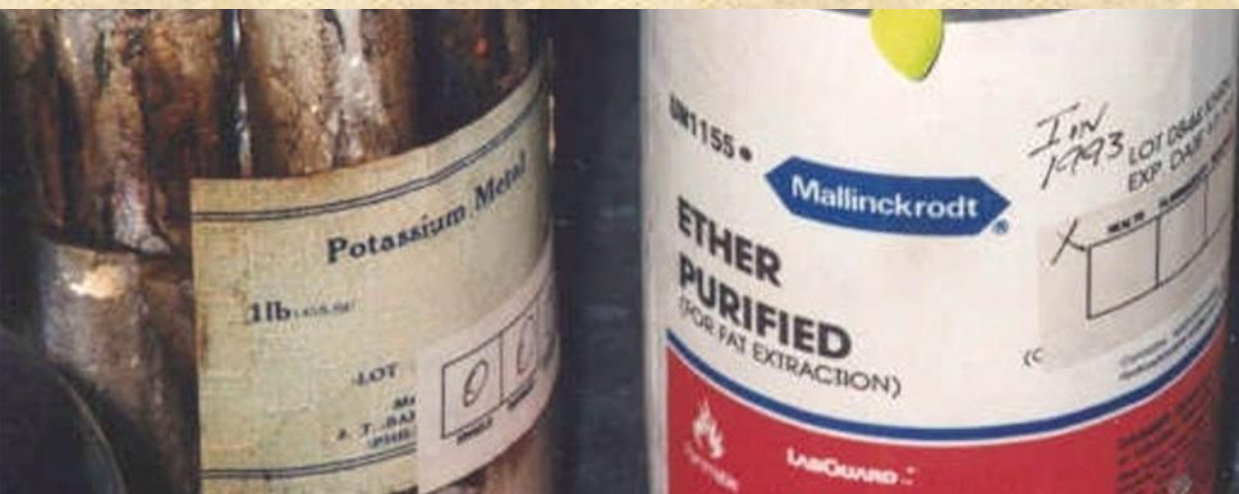
- An Introduction to Reactive & Explosive Materials
 - Hazard Productions, Inc.
 - <http://www.rhr-inc.com/hazpro.htm>
 - \$350 for the DVD

Do we know each chemical's hazards?



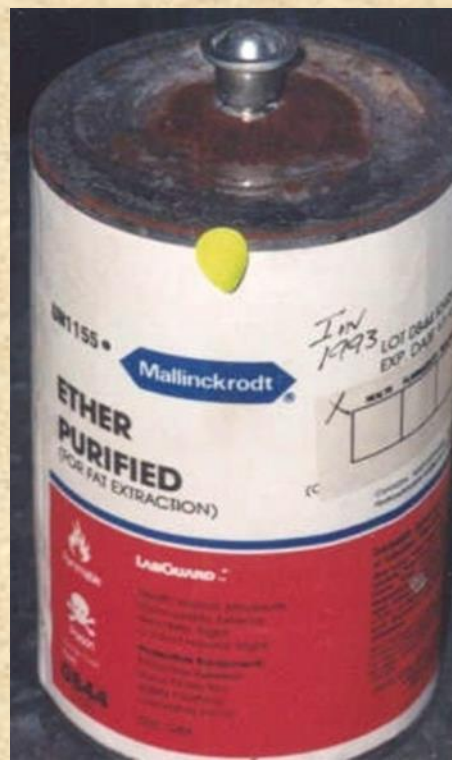
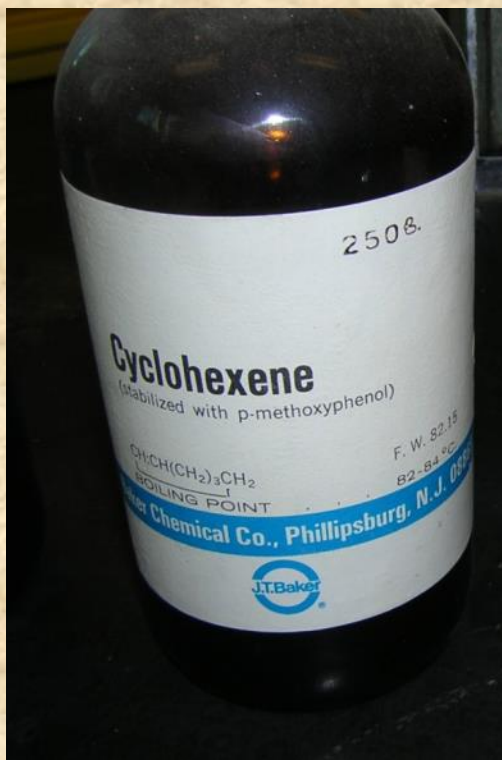
Common Explosive Chemicals

- Peroxide-formers
- Nitro organics
- Organic peroxides
- Contaminated compounds



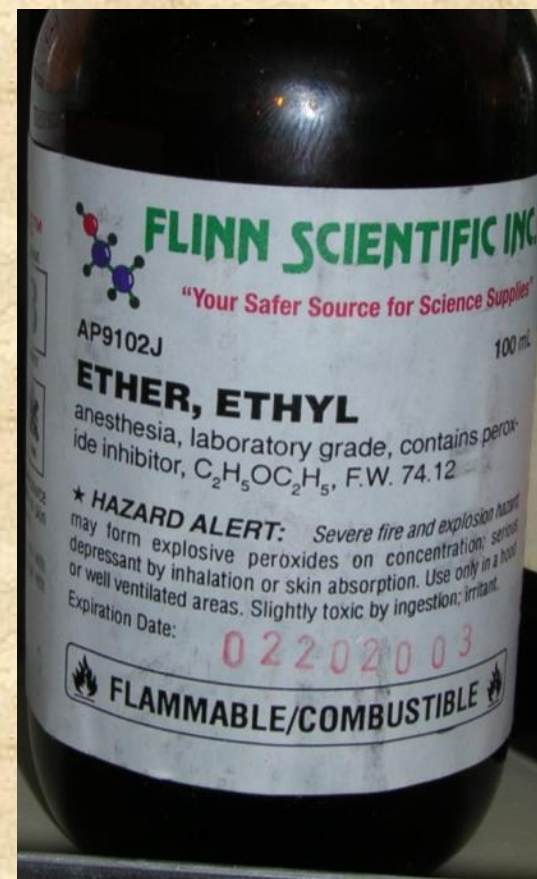
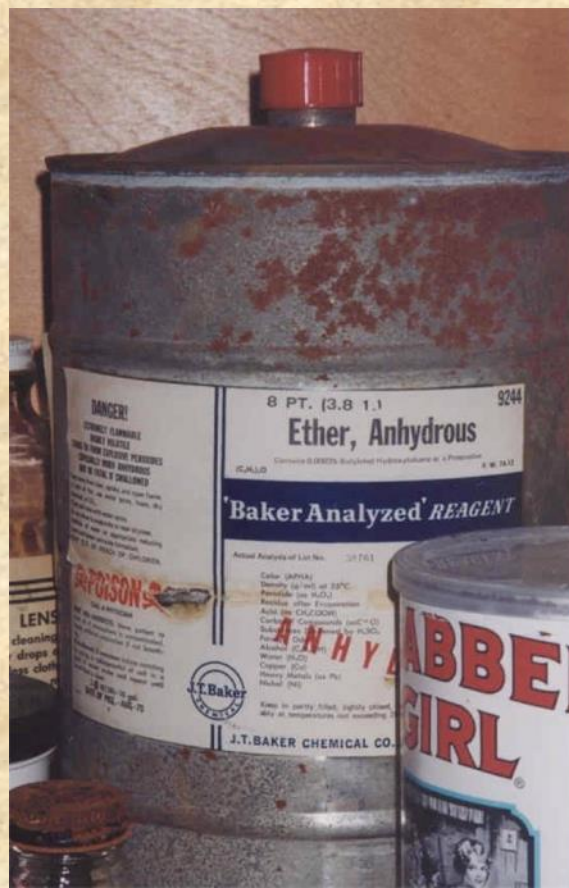
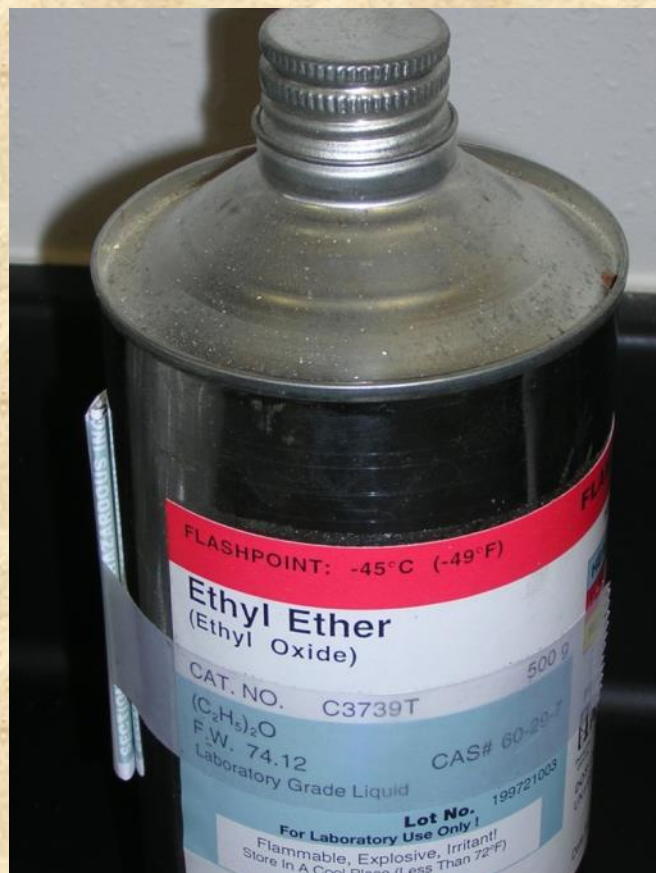
Peroxidizable Solvents

- Peroxides form when vapors mix with oxygen – usually in cap's threads
- Shock sensitive explosives



Diethyl Ether is Most Common

- aka – Ether, Ethyl Oxide, Ethyl Ether
- Used as anesthetic & organic solvent



Scariest One You May Find

Isopropyl Ether = Bomb Squad

They took bottle outside, spontaneously shattered

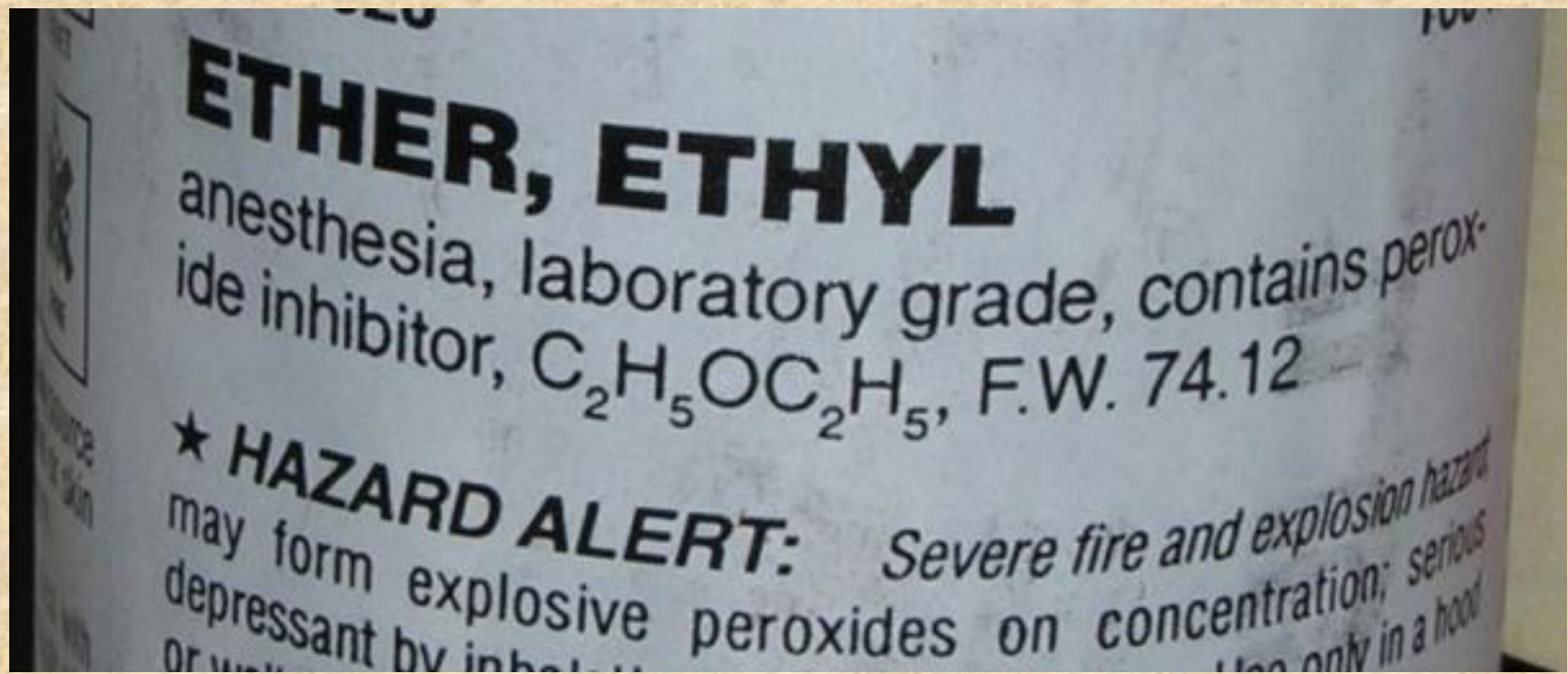


It then Auto-Detonated
Shock and Light-sensitive



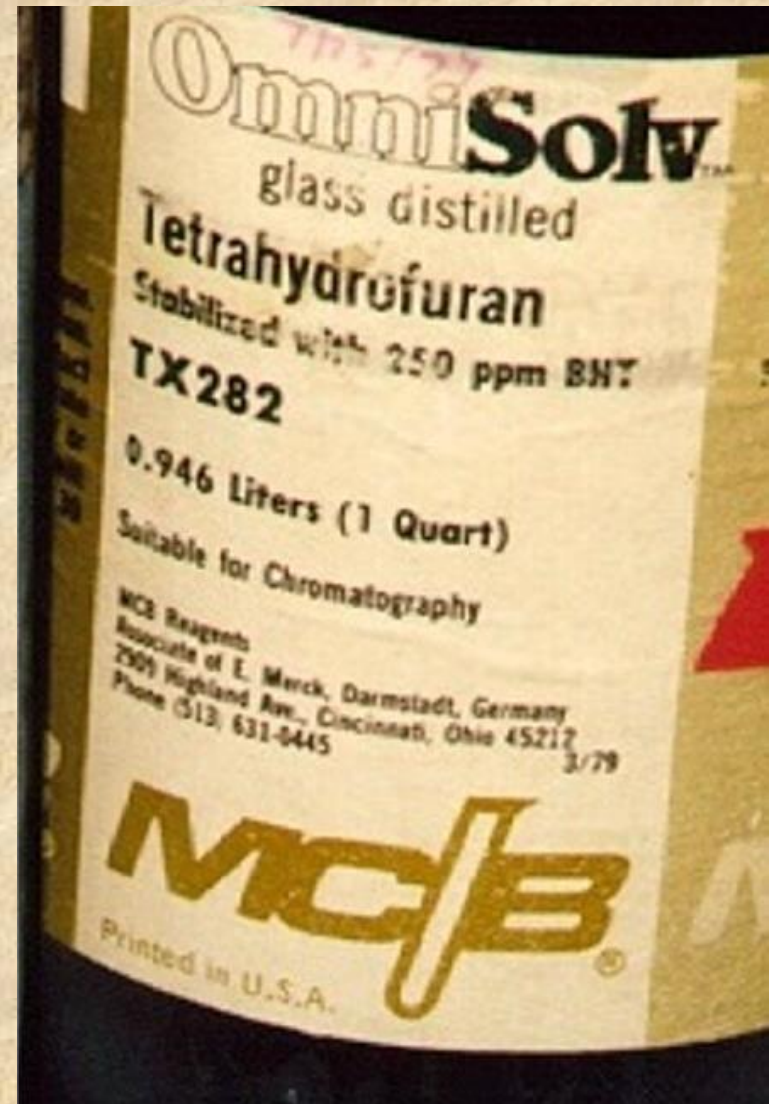
Peroxide Inhibitors

- Typically around 200 ppm BHT
 - Butylated Hydroxytoluene
- >200 ppm peroxides form, BHT is gone



How Storage Can Affect Hazards

- Flammable
- Peroxide former
- Stabilizer: BHT
- Stored in a freezer
- BHT is temp. sensitive
- THF flash point = 7° F
- Enhanced explosion risk



One way to test ether for peroxides

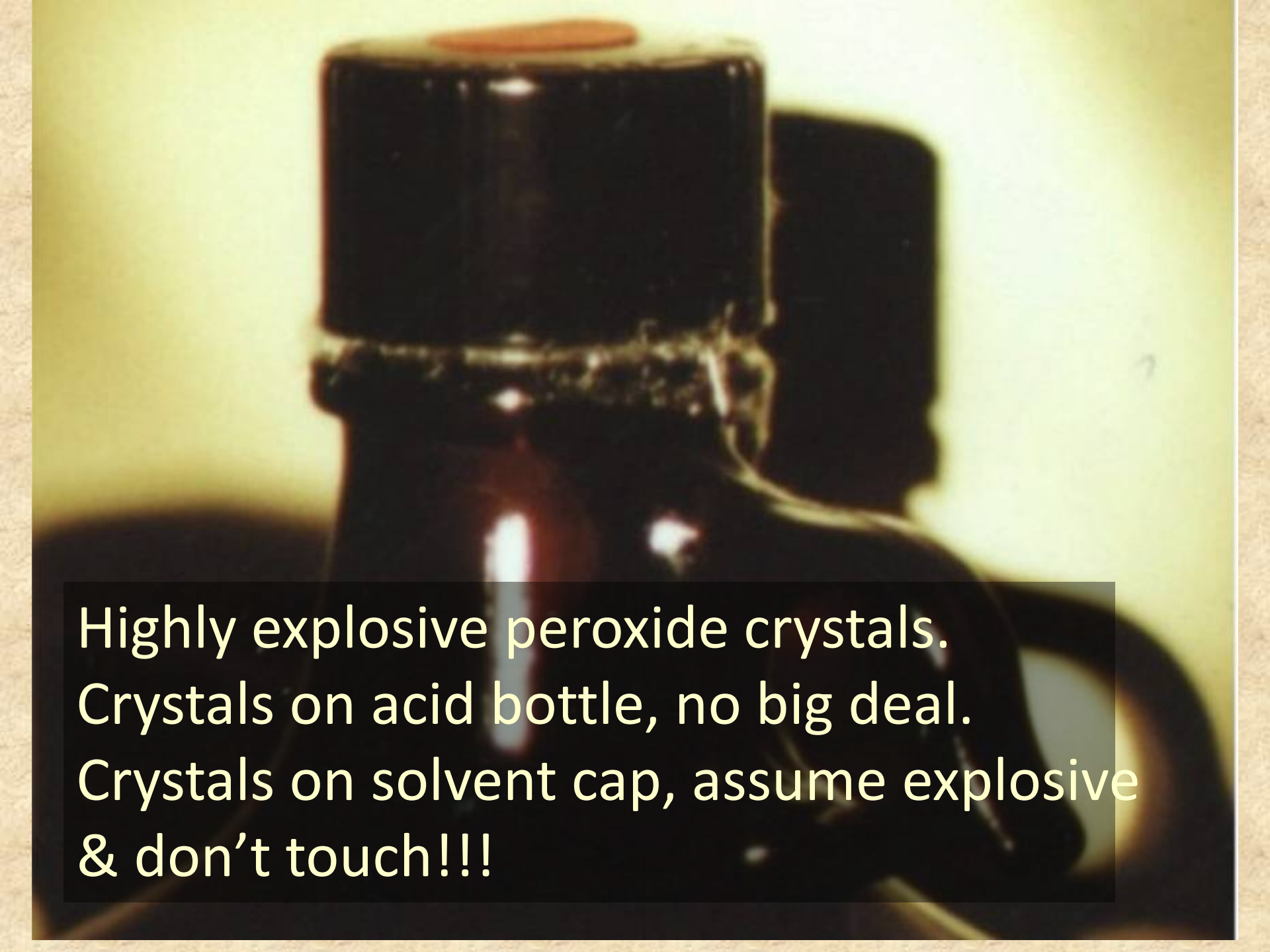


Half Pint of Ethyl Ether



25 Foot Fireball





Highly explosive peroxide crystals.
Crystals on acid bottle, no big deal.
Crystals on solvent cap, assume explosive
& don't touch!!!

“Grandpa died, left a full garage”



- Chemicals on front porch
- Garage too full to hold them
- Grandpa worked in mining
- Acids, adhesives, etchants, metal powders, unknowns



Unknown Lumps in Jar



“I think that may be potassium.
I saw a label somewhere”

- Diagnostic lumps
- Our labeling
- Purple spot



Potassium & Sodium Oxidizing

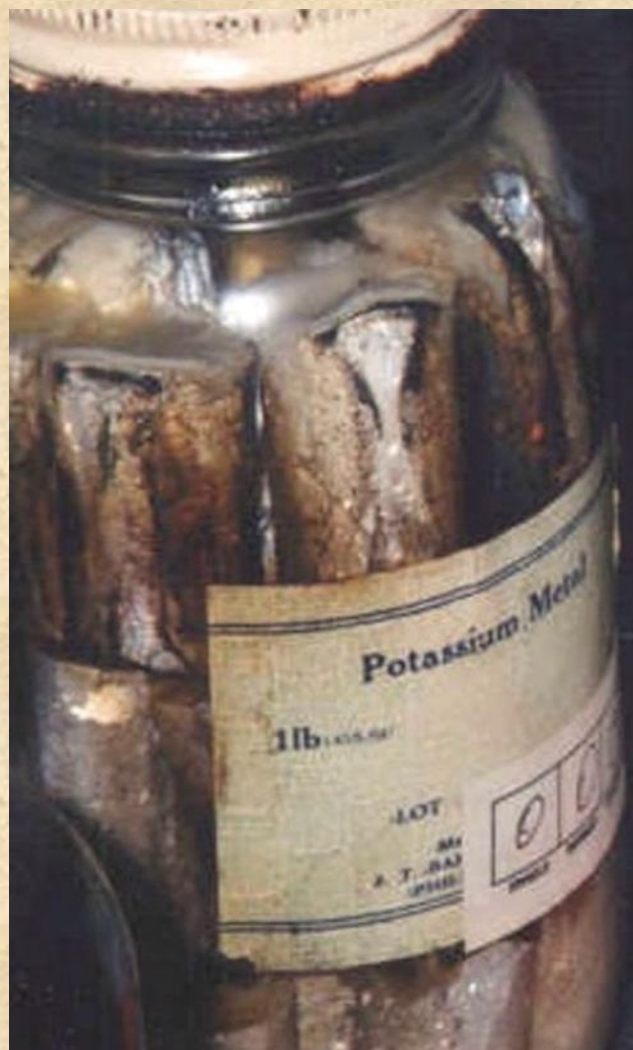


The left photograph shows a large, glowing, molten mass of a metal, likely potassium or sodium, in a dark container. The metal is highly reactive and oxidizing, as evidenced by the intense orange and yellow colors. The right photograph shows a glass jar containing a white, crystalline substance, likely sodium or potassium. The jar has a label that reads "Sodium" and "DANGER!". The label also includes safety information and the manufacturer's name, "MCEB".



Solid Potassium Metal

Peroxide Former & Water Reactive



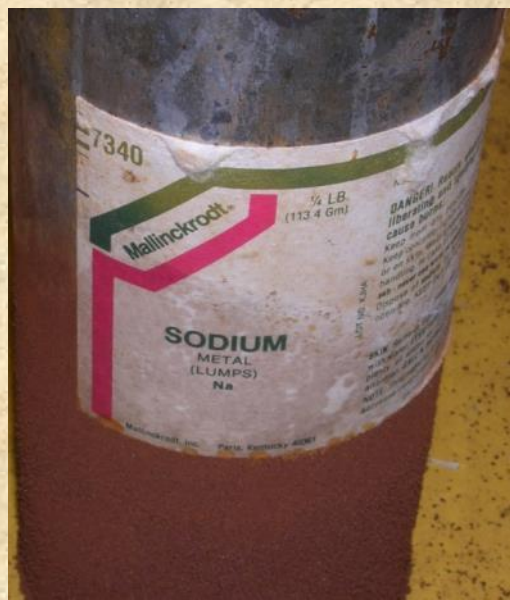
Potassium Metal (K_2) – Color Key

- Silver – Potassium metal -Water Reactive
- White – P. Hydroxide – Corrosive
- Yellow/Orange – P. Superoxide
 - Water reactive, corrosive, unstable
- Red – P. Ozonide - Highly reactive, explosive



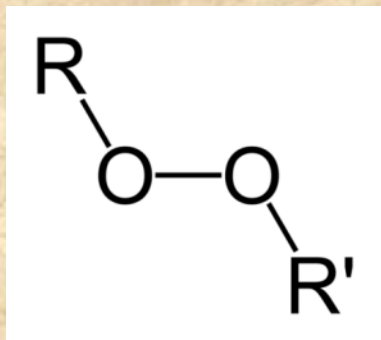
Sodium – Highly Water Reactive

- Store under oil
- Degrades to become much more reactive
- Can detonate in water



Peroxidizable Compounds We've Seen

- Peroxides without concentration
 - Isopropyl Ether
 - Potassium Amide
 - **Potassium Metal**
 - Sodium Amide



- Peroxides if concentrated by evaporation & distillation
 - **Acetaldehyde**
 - Benzyl Alcohol
 - Cumene
 - Cyclohexanol
 - **Cyclohexene**
 - **Diethyl Ether**
 - Dioxane
 - Methyl Isobutyl Ketone
 - **Tetrahydrofuran**
 - Vinyl Ether

Office for Research Safety

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[Home](#) >> [Safety Information](#) >> [Chemical](#) >> [Hazard Groups](#) >> [Peroxidizable Compounds](#)**Hazard Groups**[Corrosives: Acids and Bases](#)[Flammable and Combustible Liquids](#)[Compressed Gases](#)[Cryogenic Liquids and Liquefied Gases](#)[Highly Reactive Chemicals](#)Note: The following is an excerpt of the [Chemical and Biological Safety in Laboratories](#).**Peroxidizable Compounds****List of Peroxidizable Compounds**

Acetal	Diethyl ether	Isopropyl vinyl ether
Acetaldehyde	Diethyl fumarate	2-Isopropylacrylaldehyde oxime
Acrylamide	Diethylene glycol dimethyl ether	Isovaleraldehyde
Acrylic Acid	Diethylketene	Limonene
Acrylonitrile	Diglyme	1,5-p-Menthadiene
Allyl ethyl ether	2,3-Dihydrofuran	Methoxy-1,3,5,7-cyclo octatetraene
Allyl phenyl ether	2,3-Dihydropyran	2-Methoxyethanol
Allyl vinyl ether	Diisopropyl ether*	2-Methoxyethyl vinyl ether
1-Allyloxy-2,3-epoxypropane	1,1-Dimethoxyethane	Methyl acetylene
Benzyl-1-naphthyl ether	1,2-Dimethoxyethane	Methyl methacrylate
Benzyl butyl ether	1,1-Dimethoxypropane	4-Methyl-1,3-dioxane
Benzyl ethyl ether	2,2-Dimethoxypropane	2-(1-Methylheptyl)-4,6 dinitrophenyl crotonate
Bis(2-ethoxyethyl) ether	3,3-Dimethoxypropene	2,3-Methyl-2-methylene butanal
Bis(2-methoxyethyl) ether	2,2-Dimethyl-1,3-dioxolane	4-Methyl-2-pentanone
1,3-Butadiene	2,6-Dimethyl-1,4-dioxane	2-Methyltetrahydrofuran
1,3-Butadiyne	1,3-Dioxane	Methyl vinyl ether
2-Butanol	1,4-Dioxane	2-Penten-4-yn-3-ol
Buten-3-yne	1,3-Dioxep-5-ene	a-Pentylcinnamaldehyde
Butyl ethyl ether	1,3-Dioxol-4-en-2-one	Potassium* (forms yellow potassium peroxide on the surface)
Butyl formate	Dipropoxymethane	Potassium amide
Butyl vinyl ether	Dipropyl ether	2-Propanol
2-Chloro-1,3-butadiene	Divinyl acetylene*	Propionaldehyde
1-Chloro-2,2-diethoxyethane	Divinyl ether	2-Propyne-1-thiol
2-Chloroacrylonitrile	1,2-Epoxy-3-isopropoxy propane	Sodium 5,8,11,14,-eicosatetraenoate
2-Chloroethyl vinyl ether	1-Ethoxy-2-propyne	Sodium amide*
Chloroethylene	2-Ethoxyethanol	Sodium ethoxyacetylde
		Styrene

Ether Starter Fluid

- Blend of ethyl ether & hexane or heptane
- Not peroxide forming



Petroleum Ether

Commonly found in schools

- Not a true ether
- Doesn't form peroxides



Collodion = Ether + Nitrocellulose



Collodion

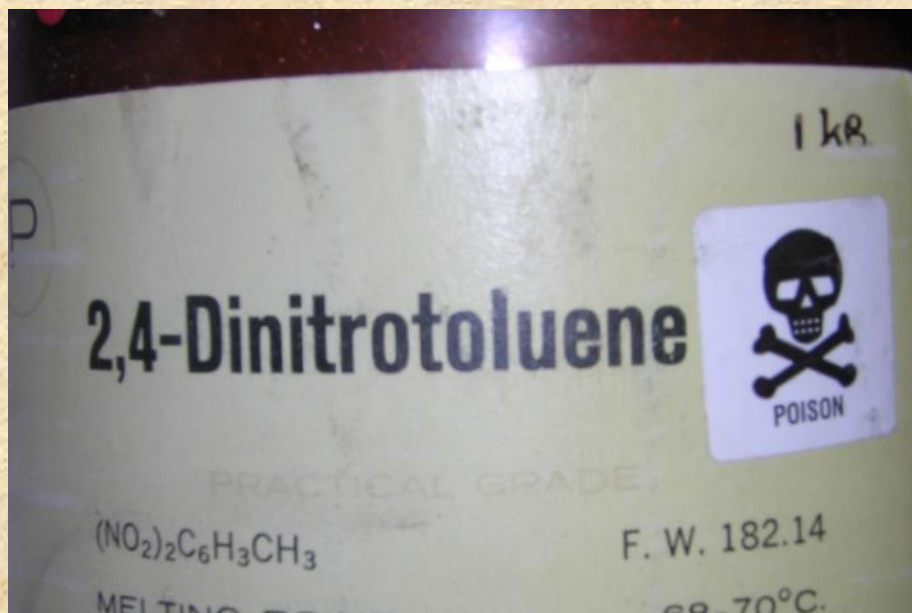
Used in Photochemistry, Science labs

- Peroxide formation risk
- Explosive reaction with nitric acid
- Shock and static sensitive



Nitro Organics

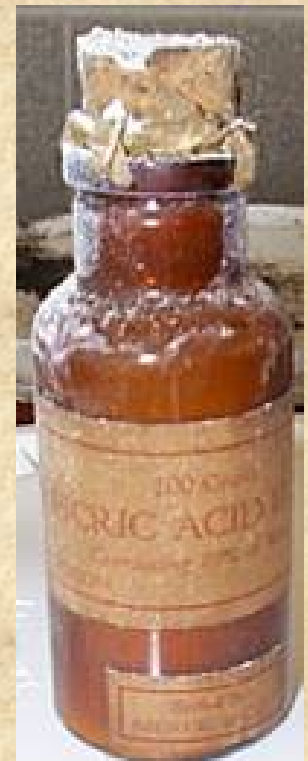
- Trinitrotoluene (TNT)
- 2,4-Dinitrotoluene
- Trinitrophenol (Picric Acid)



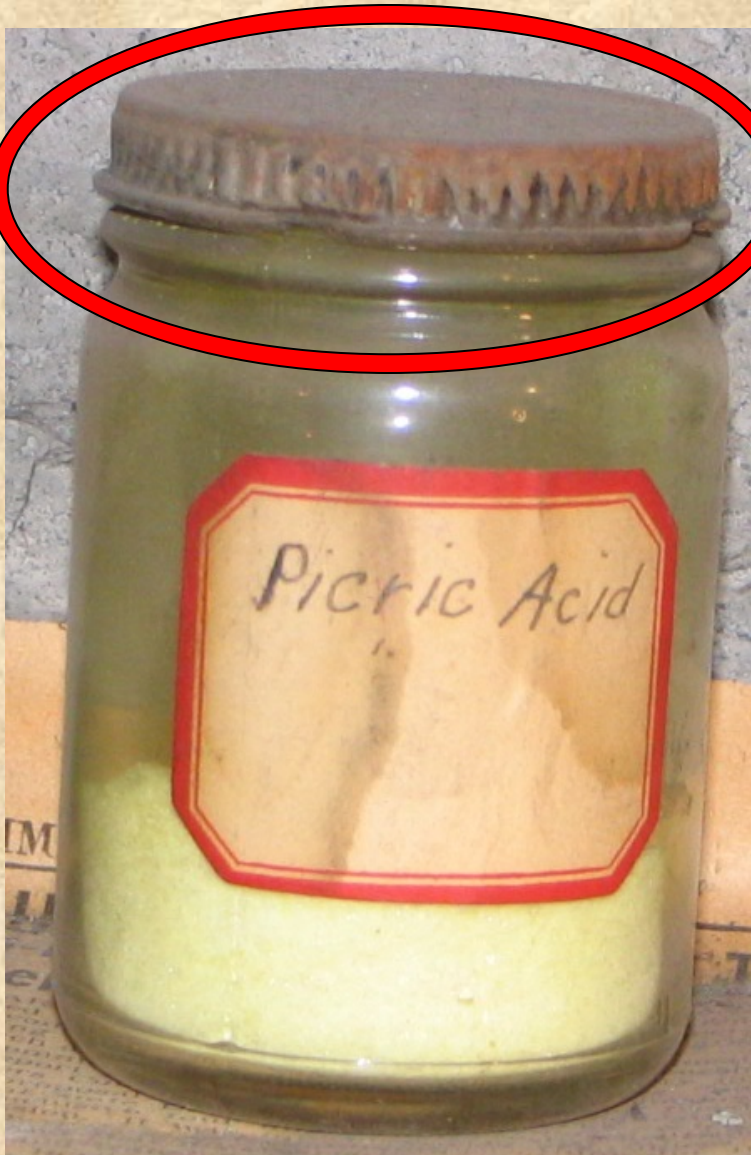
Picric Acid – Trinitrophenol

(Constituent of Bouin's Fluid)

- Shock-sensitive high explosive **when dry**
- In medical labs (stains brain cells) and schools



Metal picrates are highly shock sensitive



One pound of picric acid at HHW site
60 pound sandbags 25 feet up in tree



Photo by Ionie Wallace. Used with permission.

Nitro Organics

- Picryl compounds
- Nitromethane
- Fulminates of metals
 - Fulminate ion



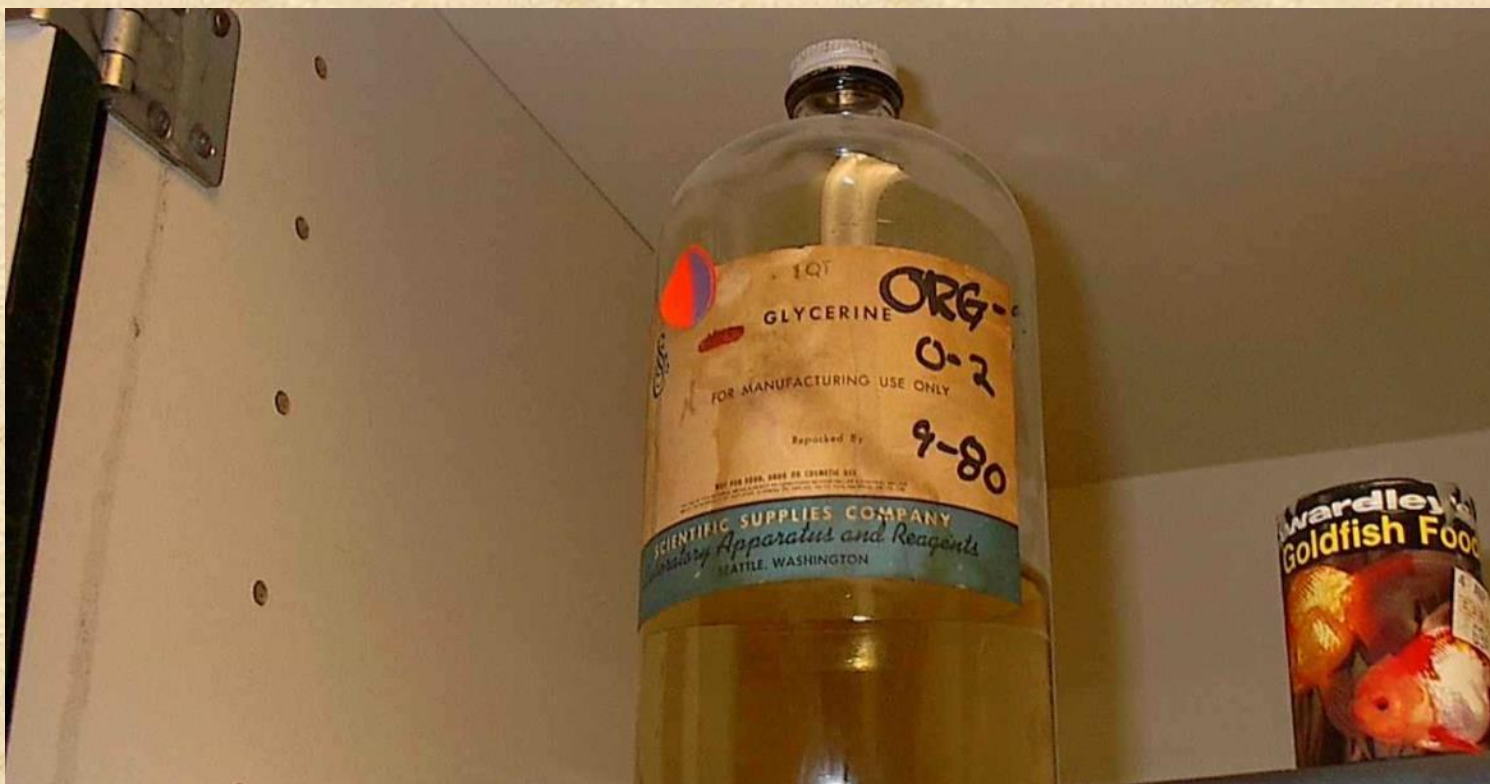
Washington State Middle School



Hand written
word "NITRO"
under red dot

Glycerine Formula $C_3H_5(OH)_3$

- Tested for nitrogen – sky high levels
- Yep, it's homemade nitroglycerine!



HIGH EXPLOSIVES

```
graph TD; A[HIGH EXPLOSIVES] --> B[PRIMARY HIGH EXPLOSIVES]; A --> C[SECONDARY HIGH EXPLOSIVES]; B --> B1[LEAD AZIDE]; B --> B2[LEAD STYPHNATE]; B --> B3[MERCURY FULMINATE]; B --> B4[DDNP]; B --> B5[TETRAZENE]; C --> D[BOOSTERS]; C --> E[MAIN CHARGE]; D --> D1[PETN]; D --> D2[RDX]; E --> E1[DYNAMITE]; E --> E2[BINARY EXPLOSIVES]; E --> E3[WATER GELS]; E --> E4[EMULSIONS]; E --> E5[TNT]; E --> E6[ANFO];
```

PRIMARY HIGH EXPLOSIVES

LEAD AZIDE

LEAD STYPHNATE

MERCURY FULMINATE

DDNP

TETRAZENE

SECONDARY HIGH EXPLOSIVES

BOOSTERS

PETN

RDX

MAIN CHARGE

DYNAMITE

BINARY EXPLOSIVES

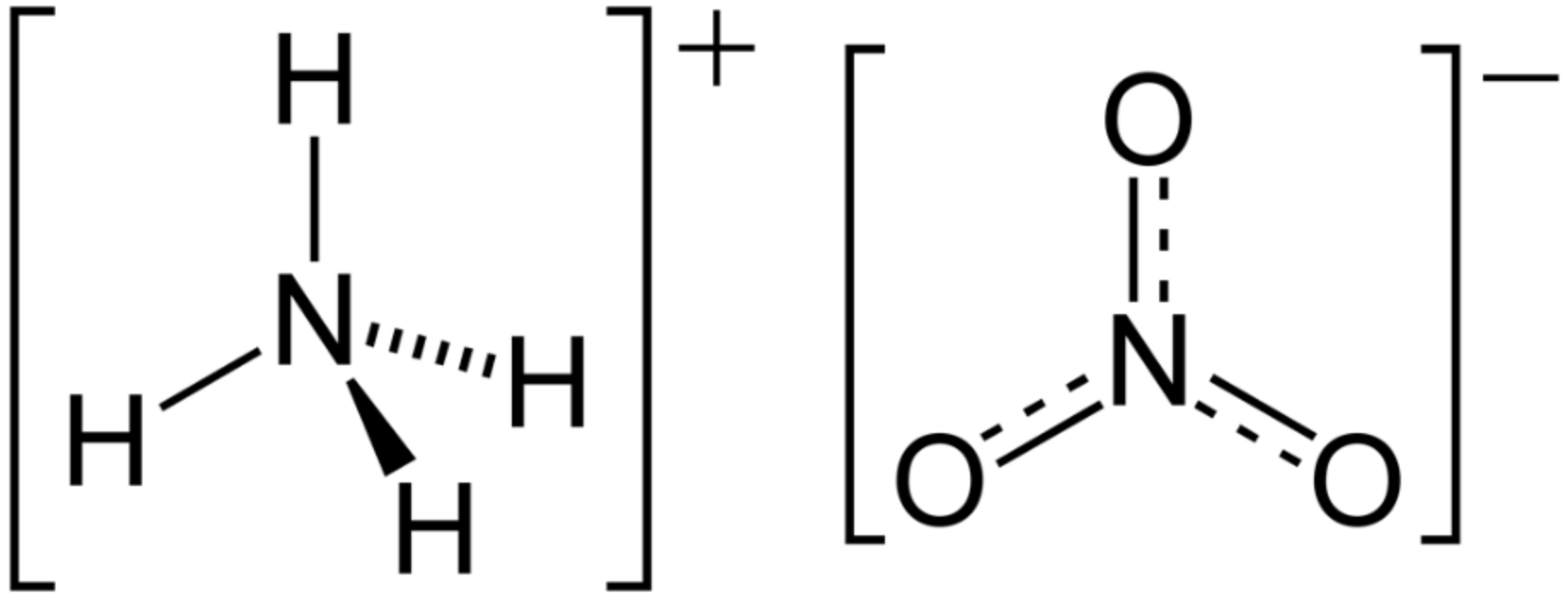
WATER GELS

EMULSIONS

TNT

ANFO

Nitrogen Rich Oxidizer



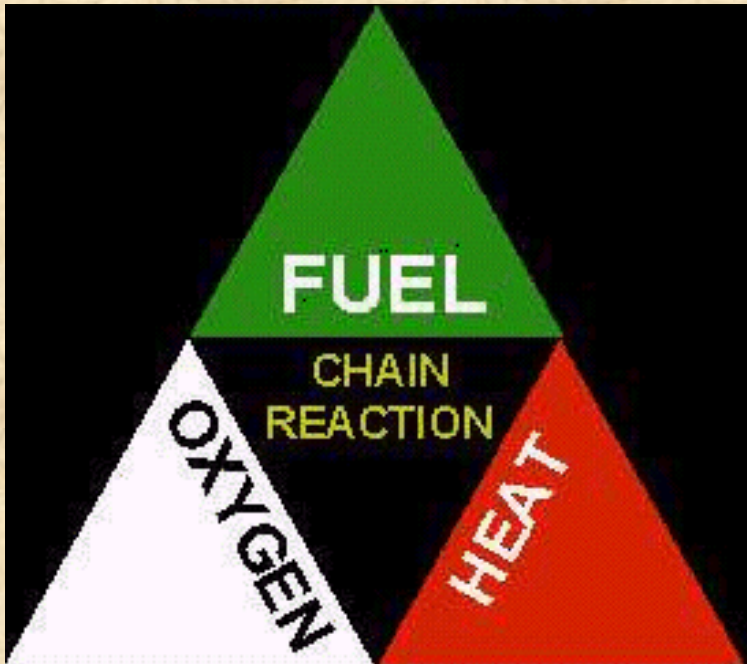
Ammonium

+

Nitrate

ANFO

- Ammonium nitrate & fuel oil mixture
- Oxidizer + organic generates heat





Silver Nitride

(aka Ammoniacal Silver Nitrate)

Tollen's Test for Aldehydes

- Waste contains silver fulminate
- Must immediately acidify solution
- If not, shock sensitive explosive
- Used in histopathology labs
- Used in mirror making



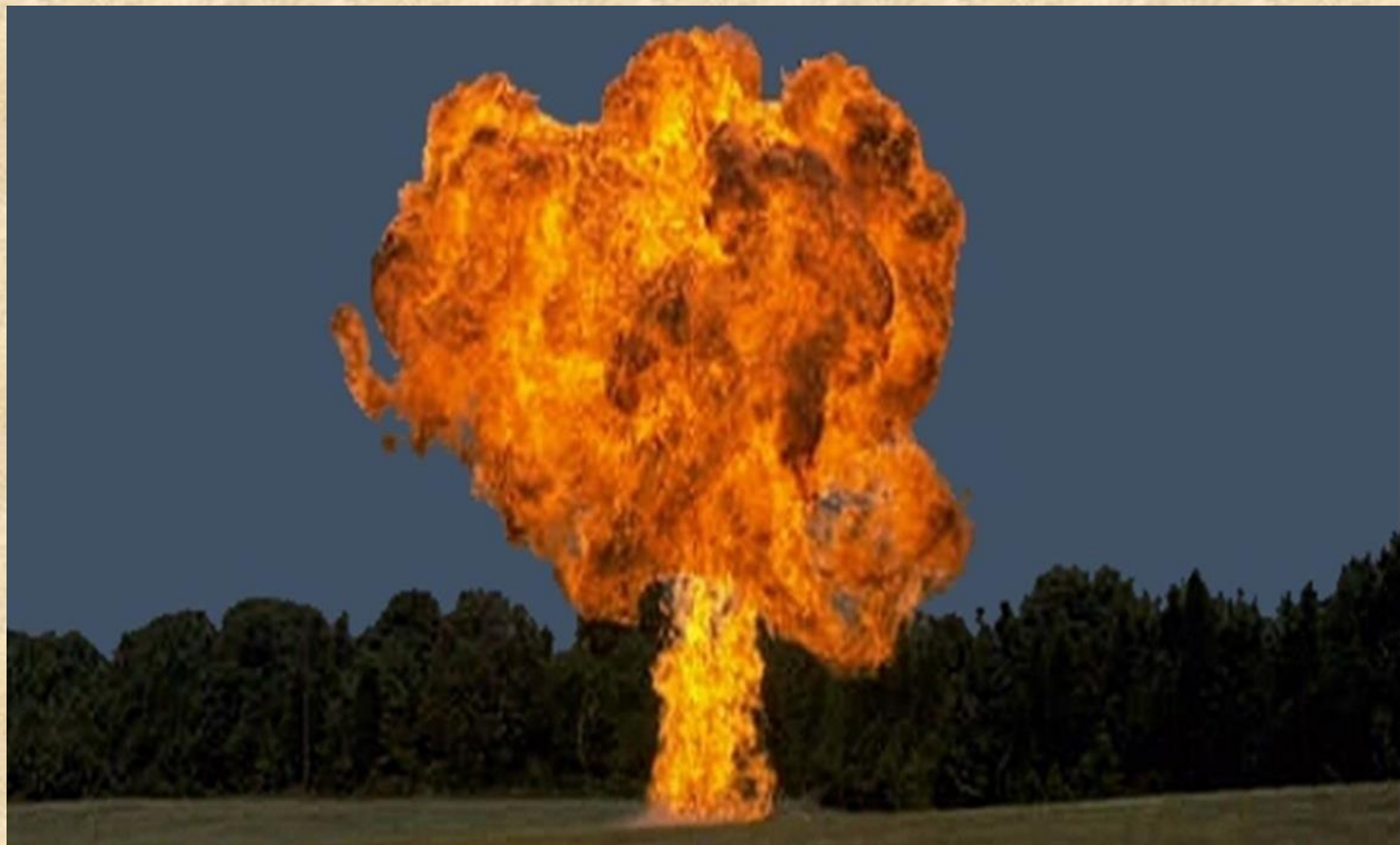
Disposing of Explosive Chemicals

- Can be very expensive
- Available options
 - Blow it up
 - Deactivate it
- Contractors are available, not cheap
- Local emergency management can help

Blowing It Up Option

Usually OK for peroxidized solvents

Serious downside if things go wrong!



Not Recommended for Solids
Tends to be incomplete explosion



Three Forms of Phosphorus

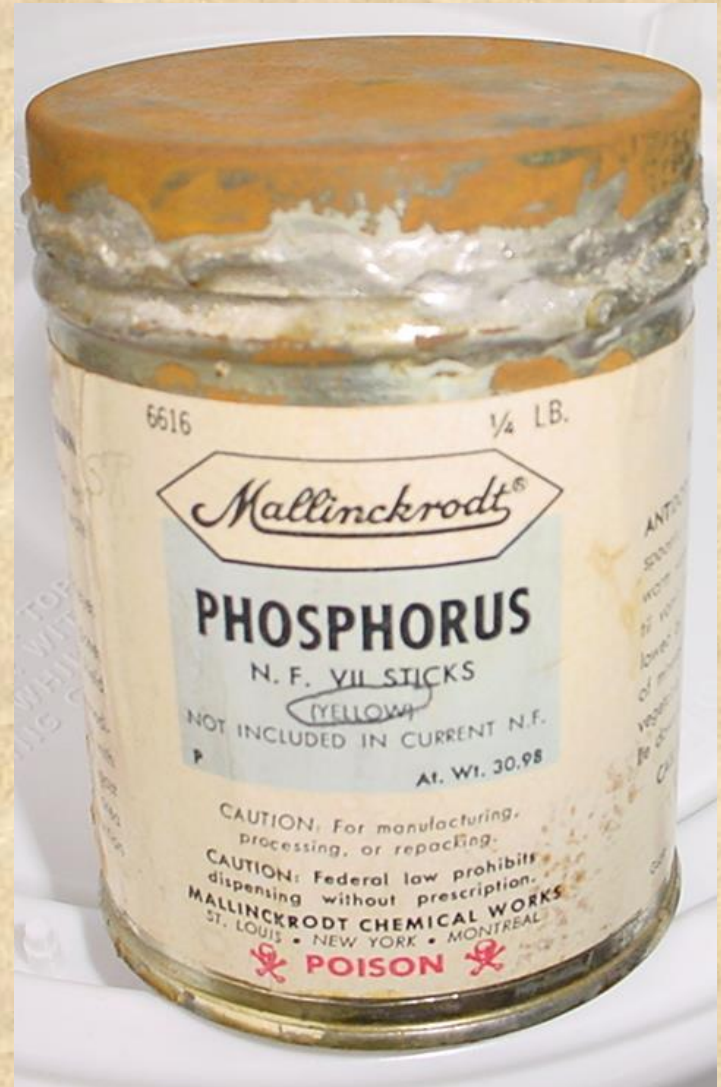
White Allotrope

- Red P – not air reactive
 - Poison
 - Flammable solid
- White & Yellow P
 - Spontaneously ignites in air (pyrophoric)
 - Stored under water
 - Note water level in jar



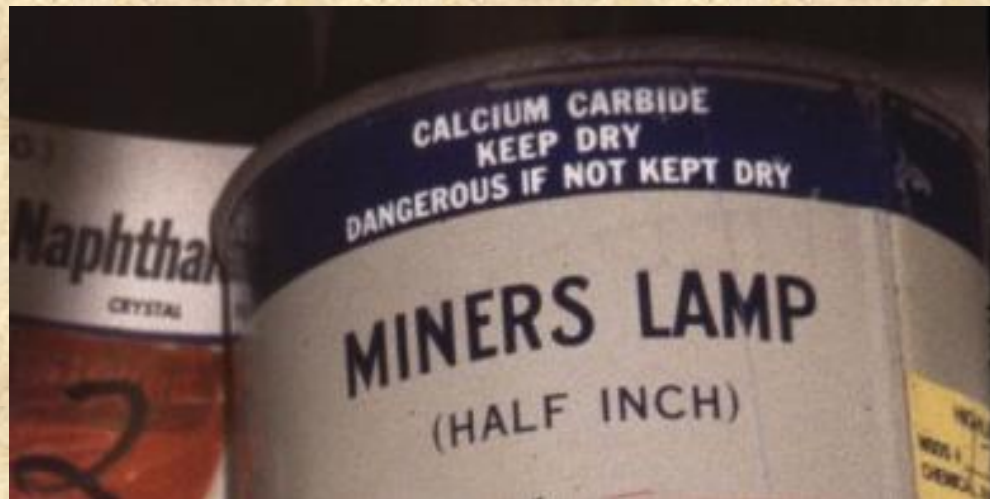
Yellow Phosphorus Containers

Can is full of water & eventually dilute acid



Common Water Reactives

- Sodium Hydrosulfite (Sodium dithionite)
- Lithium, sodium, potassium, aluminum (powder)
 - Teaching & research labs
- Calcium carbide (mining, research)
 - Releases acetylene gas



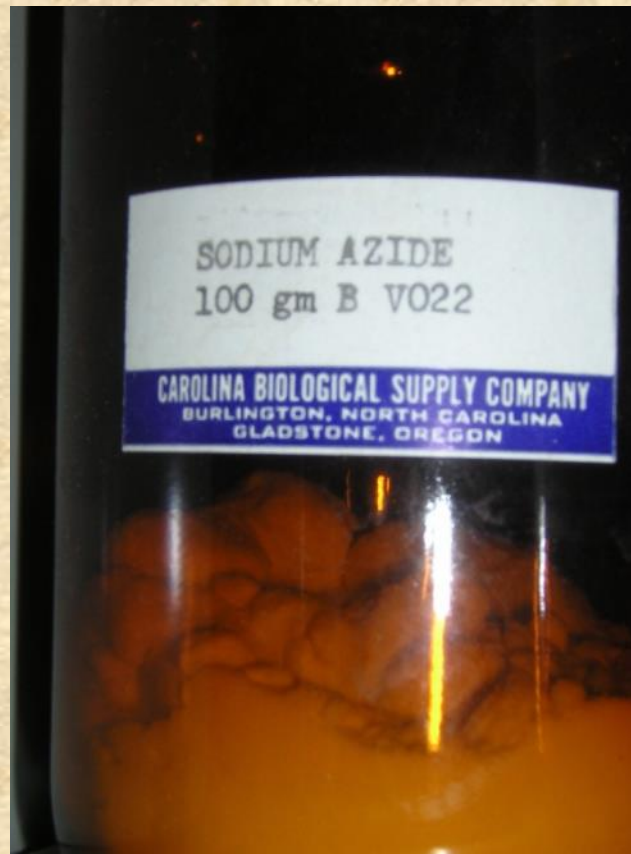
Sodium azide contaminated pipes

- Solution reacts with metal pipes
- Unused sink goes dry
- Plumbers change P-trap – **BOOM!**



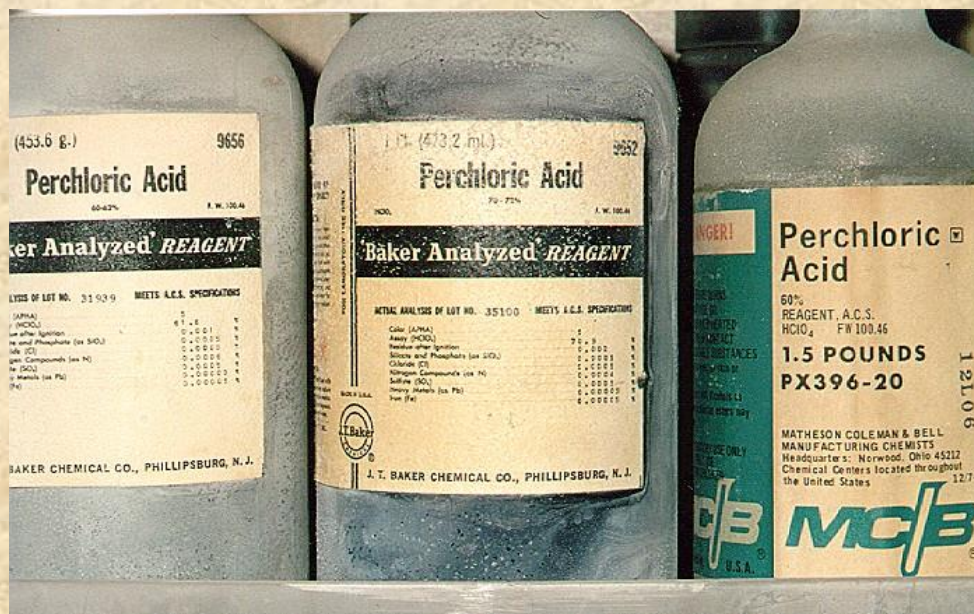
Picrates, Perchlorates, Azides

- Much more explosive as metal salts
- How can they mix with metals?

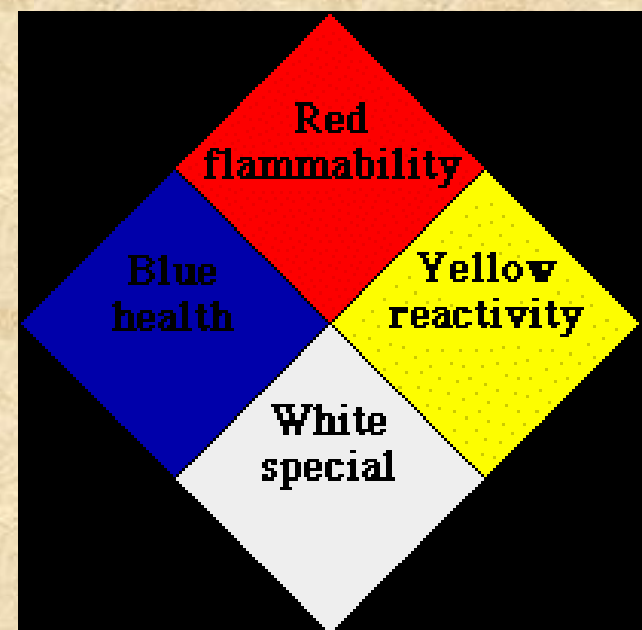
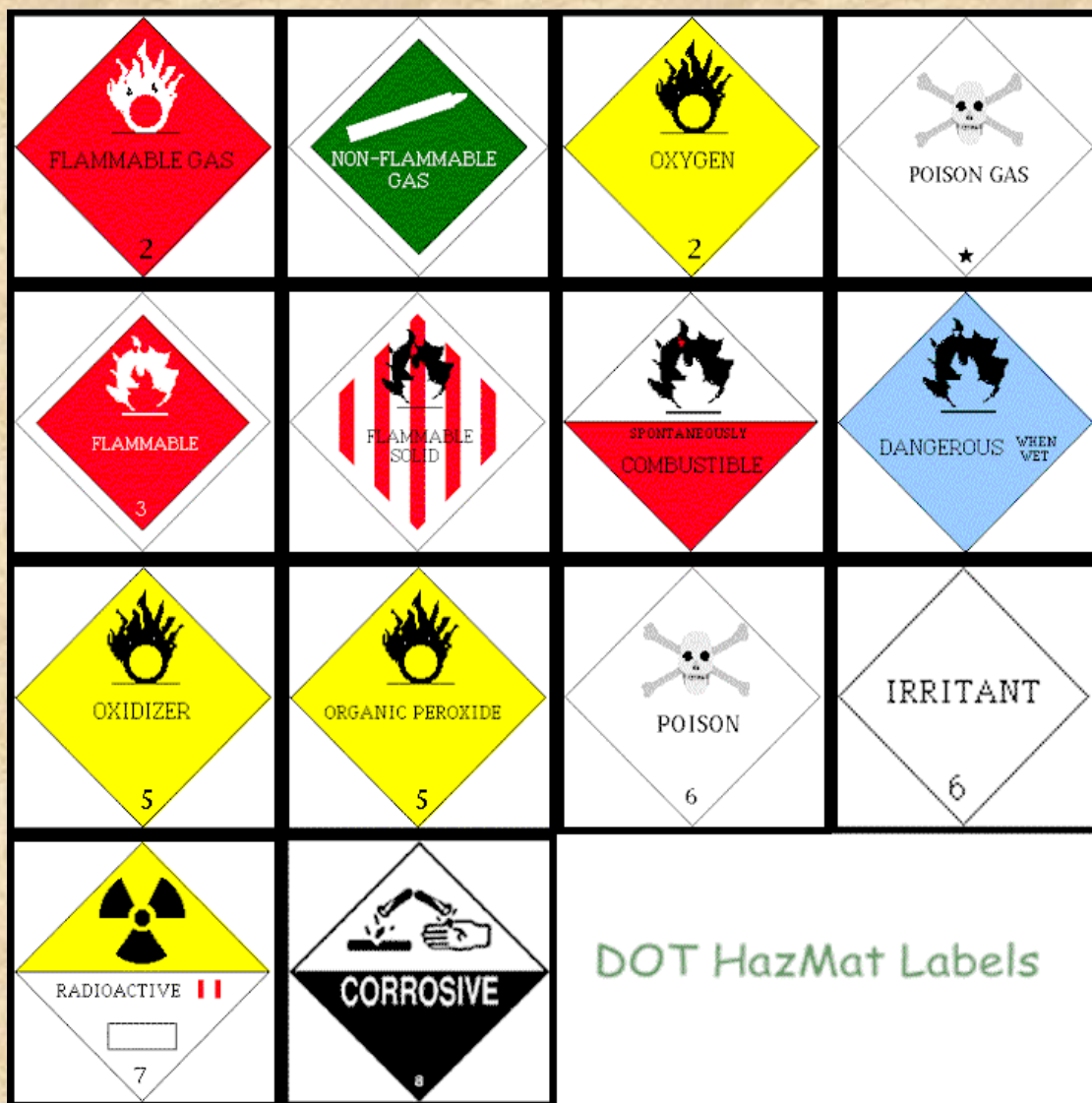


Perchloric Acid

- Powerful oxidizer
- Violent reaction with flammable organics
- If spilled on metal, metal perchlorates form
- Never store on metal shelving



Signs of Hazardous Chemicals USA



DOT HazMat Labels

Signs of Hazardous Chemicals European Union



H19A-S



H22A-S



H20A-S



H18A-S



H21A-S



H15A-S



H13A-S



H16A-S

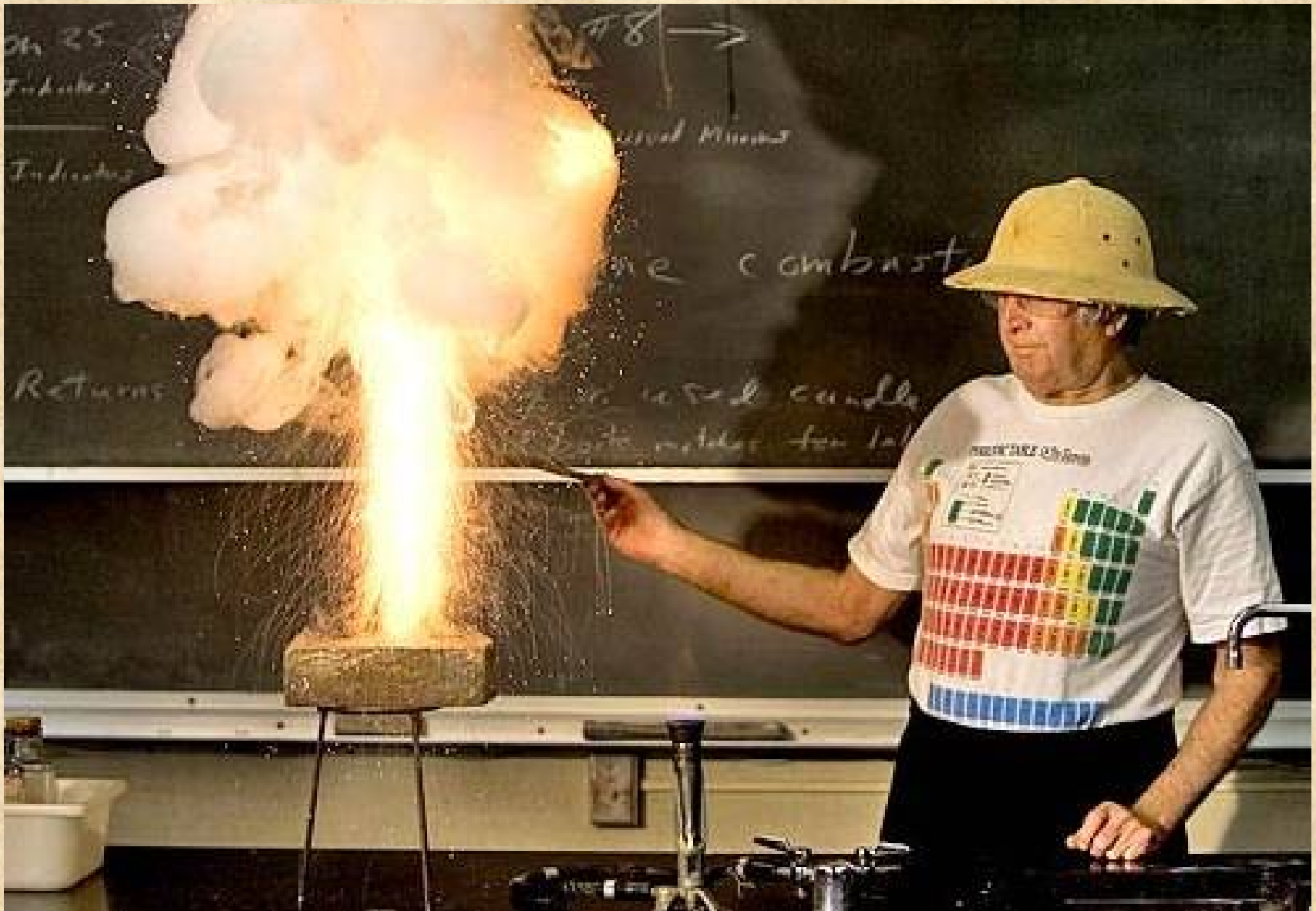


H14A-S



H17A-S

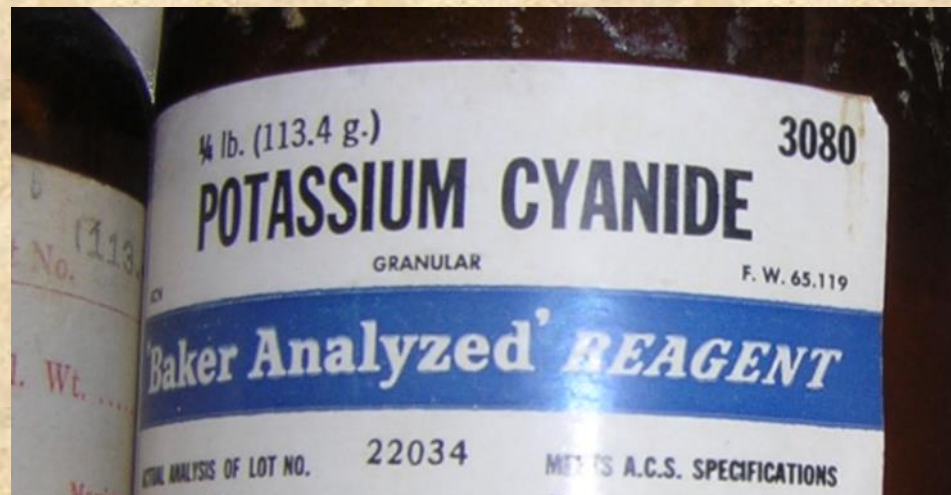
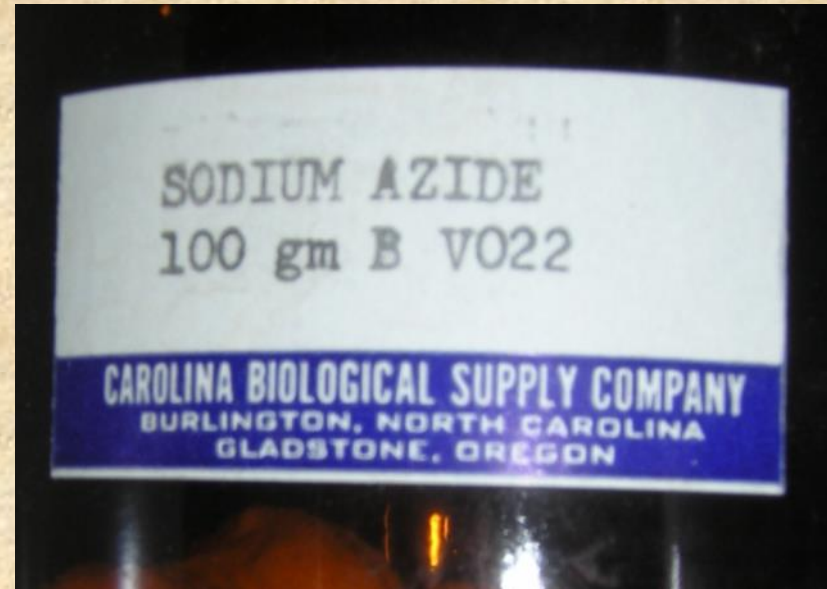
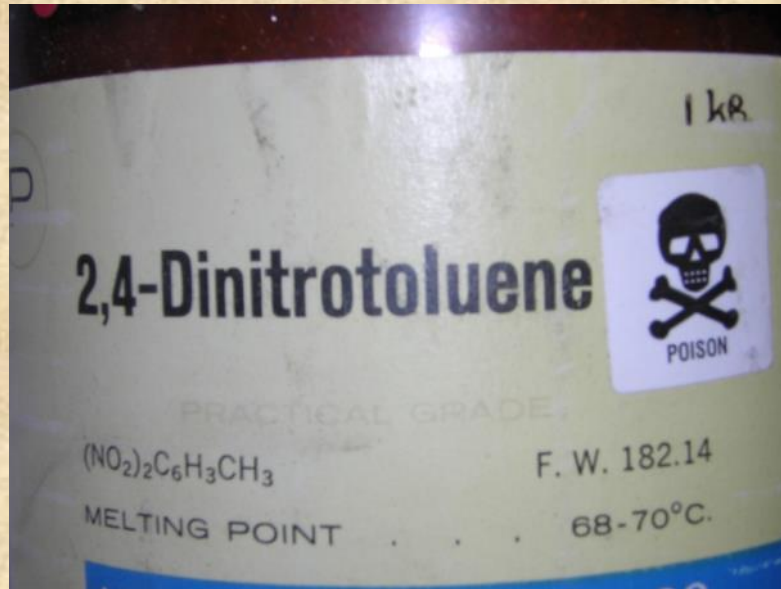
Signs of Hazardous Chemicals - Schools



We routinely find highly reactive chemicals in secondary schools



Nebraska



Tennessee



Missouri



Virginia



Iowa



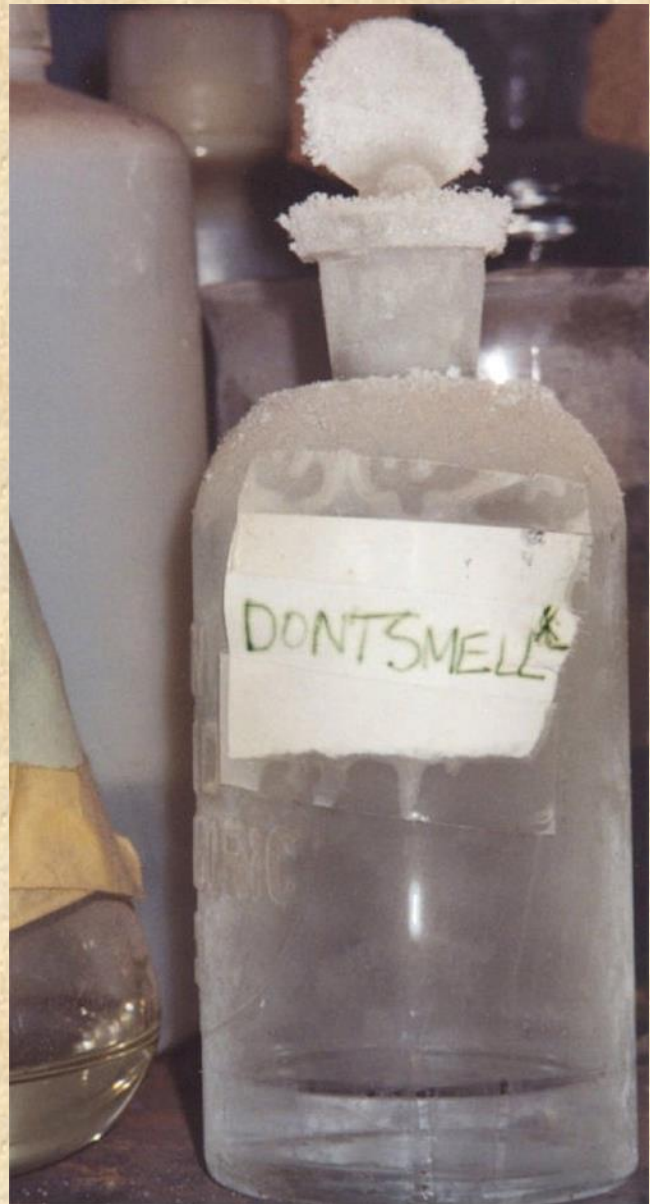
Florida



Oregon



Washington



Colorado



School chemicals list

Info on 999 chemical compounds

www.schoolchemlist.org

HAZARDOUS CHEMICALS IN SCHOOLS

[Home](#) >> [Resources for Schools](#) >> [Schools Chemical List](#)

--- Download --- 

Search for chemical name, physical, health, or environmental hazard

Search

Clear

Page 1 of 100 | 999 records |

<u>Chemical Name</u>	<u>Physical Hazard</u>	<u>Health Hazard</u>	<u>Environmental Hazard</u>	<u>Lowest Grade Allowed</u>	<u>Storage Category</u>	<u>Experiments Where Used</u>	<u>Disposal Method</u>
Abscisic Acid	--	Causes serious eye irritation Causes skin irritation May cause respiratory irritation	--	Elementary demos only	O-1	Botany - effects of plant hormones	Dispose as solid waste
Acetal	Highly flammable liquid and vapour May form explosive peroxides	Causes serious eye irritation Causes skin irritation	--	Ban Candidate	O-3 Flam Cabinet	NONE	Dispose as hazardous waste
Acetaldehyde	Extremely flammable liquid and vapour May form explosive peroxides	Causes serious eye irritation May cause respiratory irritation Suspected of causing cancer	--	Ban Candidate	O-3 Flam Cabinet	NONE. Formerly used as: Organic substrate in organic reactions.	Highly reactive chemical - assessment required before disposal
Acetamide	--	Suspected of causing cancer	--	Middle School	O-2	Melting points. Heat of fusion (enthalpy) experiments.	Dispose as hazardous waste
Acetanilide	--	Harmful if swallowed	--	High School	O-2	Organic substrate used in organic reactions.	Dispose as hazardous waste

explo

Search

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<u>Chemical Name</u>	<u>Physical Hazard</u>	<u>Health Hazard</u>	<u>Environmental Hazard</u>	<u>Lowest Grade Allowed</u>	<u>Storage Category</u>
Acetal	Highly flammable liquid and vapour May form explosive peroxides	Causes serious eye irritation Causes skin irritation	--	Ban Candidate	O-3 Flam Cabinet
Acetaldehyde	Extremely flammable liquid and vapour May form explosive peroxides	Causes serious eye irritation May cause respiratory irritation Suspected of causing cancer	--	Ban Candidate	O-3 Flam Cabinet
Acetylene	Explosive with or without contact with air Extremely flammable gas	--	--	Purchase restricted to use in welding shop.	Gas - Flammable
Acrylic Acid	Flammable liquid and vapour May form explosive peroxides	Causes severe skin burns and eye damage Harmful if inhaled Harmful if swallowed Harmful in contact with skin	Very toxic to aquatic life	Ban Candidate	O-1 Flam Cabinet

cancer

Search

> | 131 records |

Ammonium Chromate	--	May cause an allergic skin reaction May cause cancer	Very toxic to aquatic life Very toxic to aquatic life with long lasting effects	High School
Ammonium Dichromate	May intensify fire; oxidizer	Causes damage to organs through prolonged or repeated exposure Causes severe skin burns and eye damage Fatal if inhaled Harmful in contact with skin May cause allergy or asthma symptoms or breathing difficulties if inhaled May cause an allergic skin reaction May cause cancer May cause genetic defects May damage fertility or the unborn child Toxic if swallowed	Very toxic to aquatic life Very toxic to aquatic life with long lasting effects	High school w/ chemical hygiene officer approval

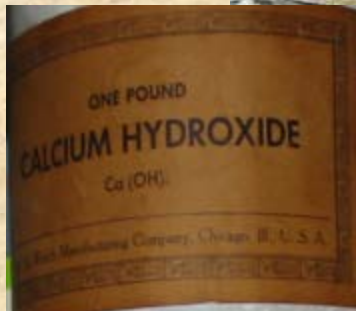
in contact with water

Search

| [View All 19 records](#) |

<u>Chemical Name</u>	<u>Physical Hazard</u>
Aluminum - Powder	Flammable solid In contact with water releases flammable gas
Barium - Metal Lump	In contact with water releases flammable gas
Calcium - Metal Lump	In contact with water releases flammable gas

Antiques Require Care





1910



1920



1940



1950



1960



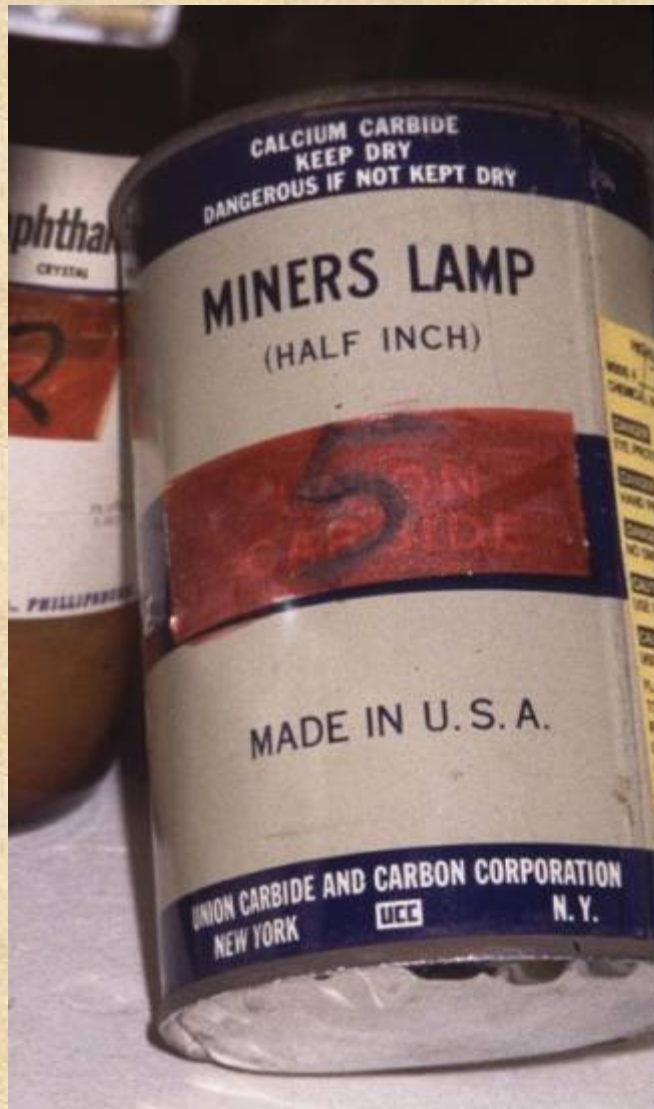
1960

So what if they're old?
Containers & contents degrade



Bulging Containers

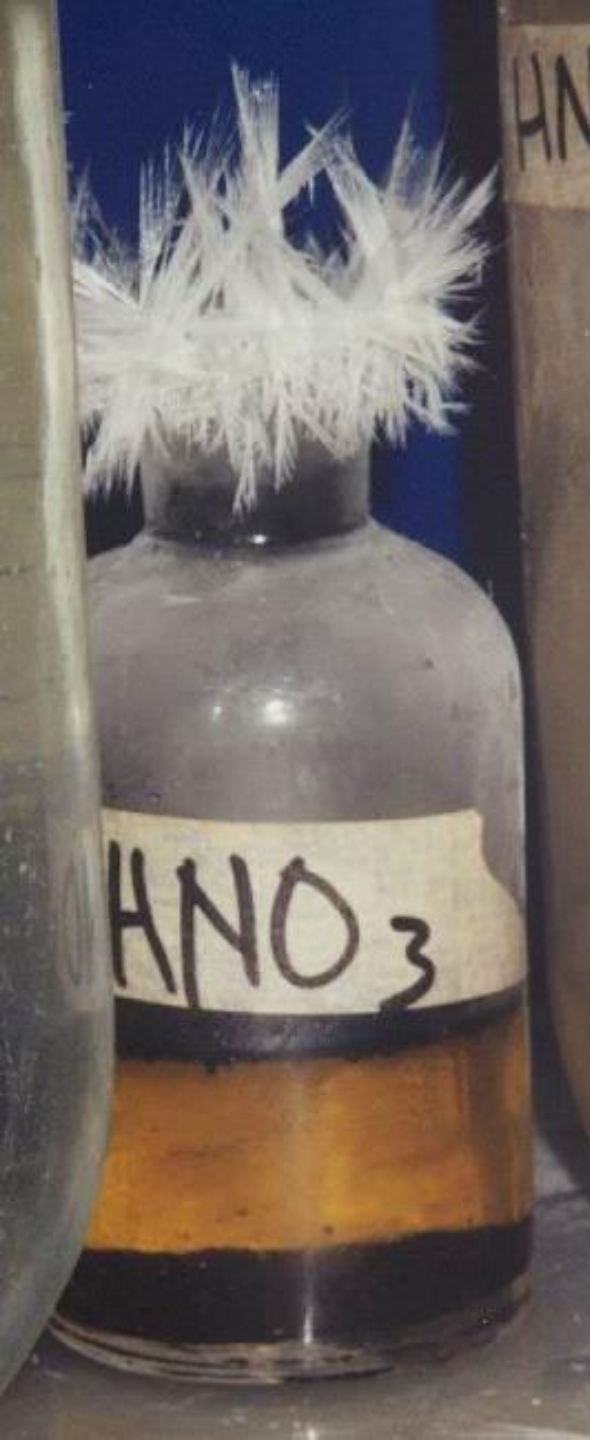
Pressurized contents? – Incompatibles mixed?



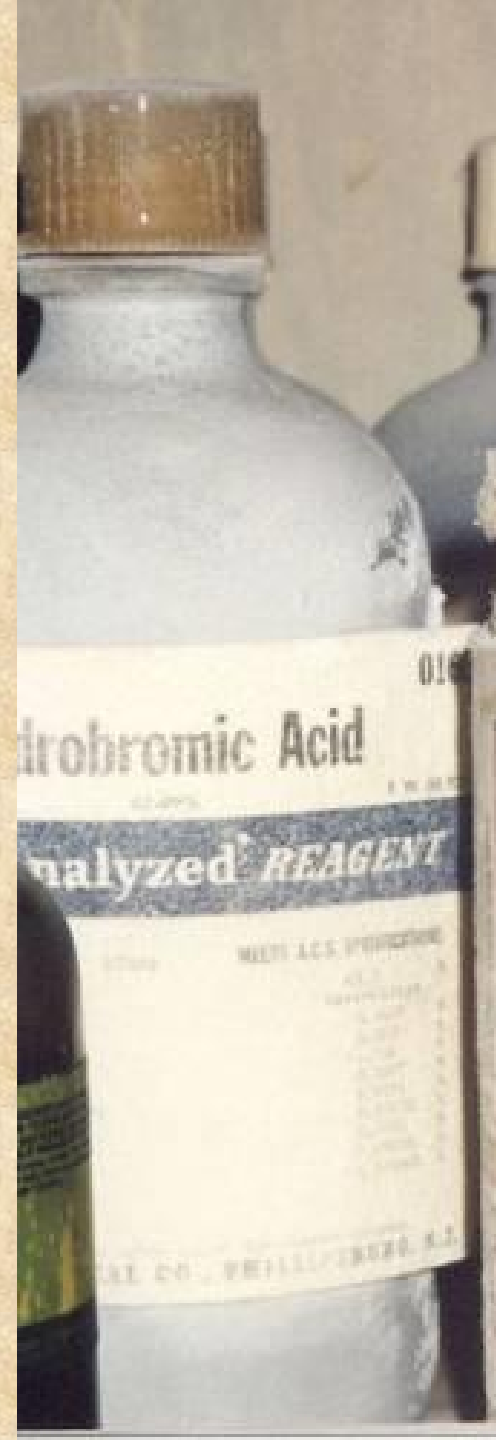
Tool to Open Bulging Containers

40 feet of line attached to it.





Something's
wrong in the
Acid Cabinet



Funky looking acid bottles
This is NOT normal



Hydrofluoric Acid

- Anesthetic
- Bone disintegration
- Dissolves glass
- Extreme pain,
- Gangrene, amputation
- Heart arrhythmia

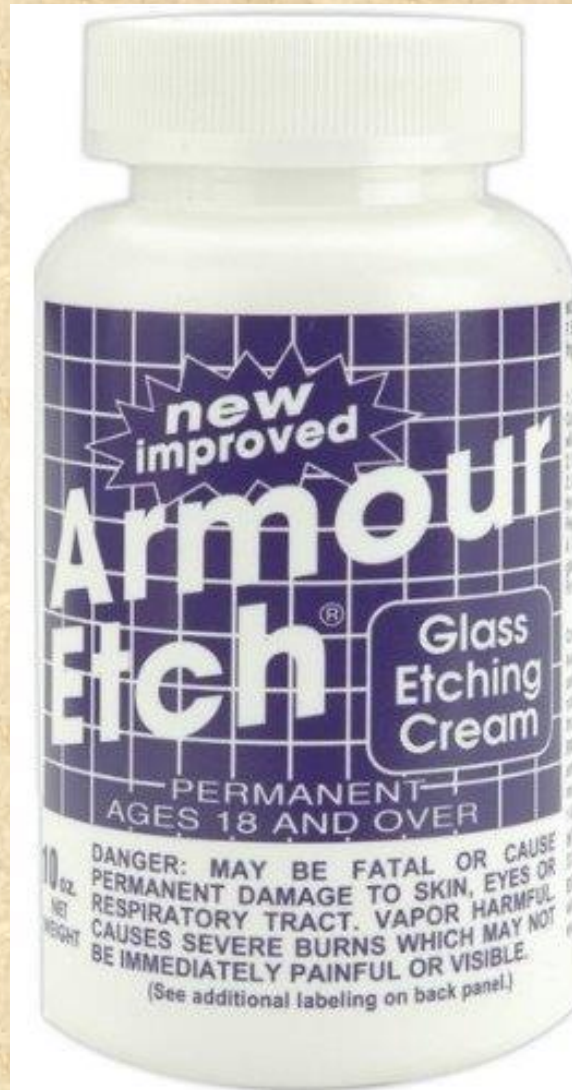


Hydrofluoric (HF) Acid Spill 1995

- 200 mls of HF on both thighs
- Burns to 9% of body, despite washing legs
- Contaminated clothing not removed
- Right leg amputated 7 days later
- Died 8 days later



Ammonium Bifluoride Etch

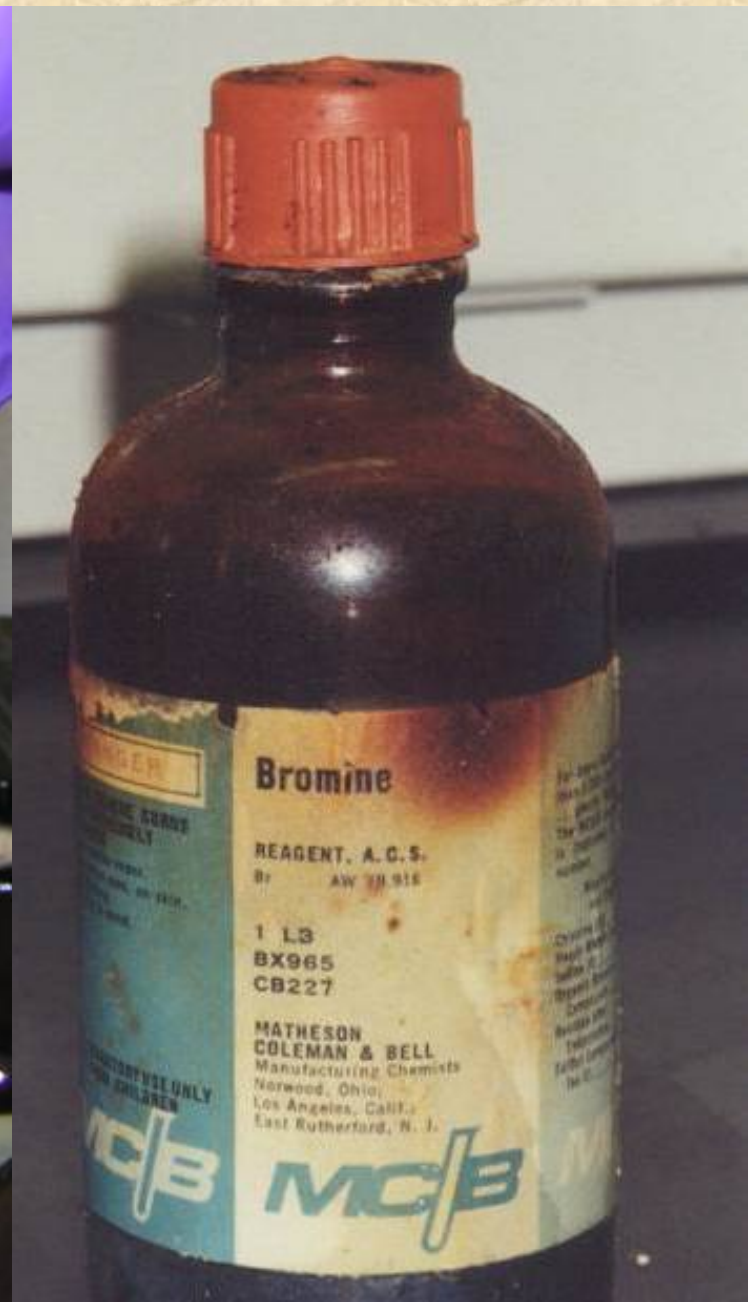


Nitric Acid (HNO_3)

Oxidizer, Corrosive & Cap Eater



Toxic Inhalation Hazards





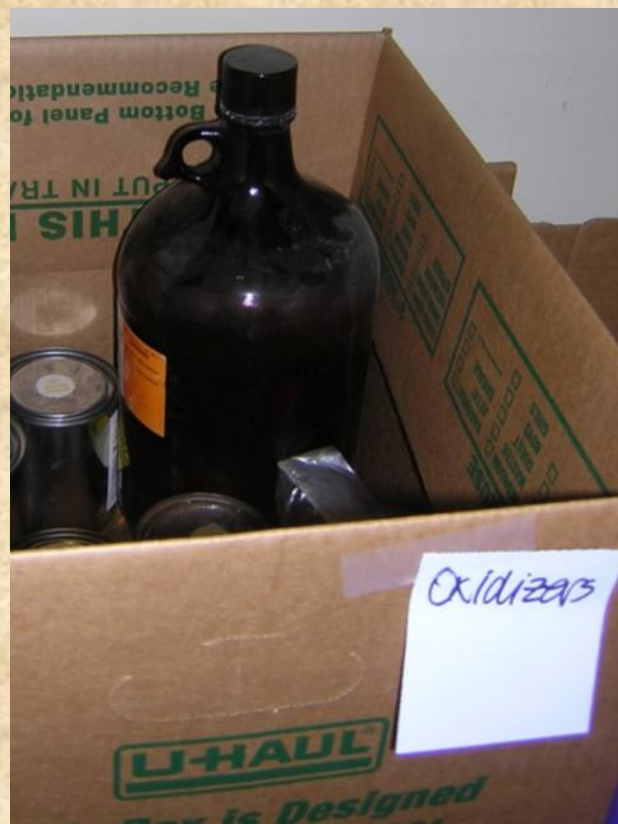
Chloroform	<p>Slightly toxic by ingestion & inhalation. Reacts with light to form poison phosgene gas.</p> <p>Carcinogen</p>
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What's wrong with this picture?



Unfortunate Mixtures

- Incompatibles together in lab or car
- Combine chemicals to fill bottles



HHW COLLECTION



THIS WAY

PENNSTATE



Pesticide Education Program

Heading to the HHW Site?



Fortunately This Was Just Latex Paint



Chemicals in Foreclosed Homes



HHW Phone Calls Can Offer Clues

- Spouses of certain deceased professionals
 - Pharmacists, doctors, teachers
- Hobby chemists



“My dead uncle was an alchemist”



“This guy’s a hoarder with a warehouse full of chemicals”



“My schizophrenic physicist brother dabbled in chemistry in mom’s garage”





A CAUTIONARY TALE

FARMER
DAVE'S
COWS

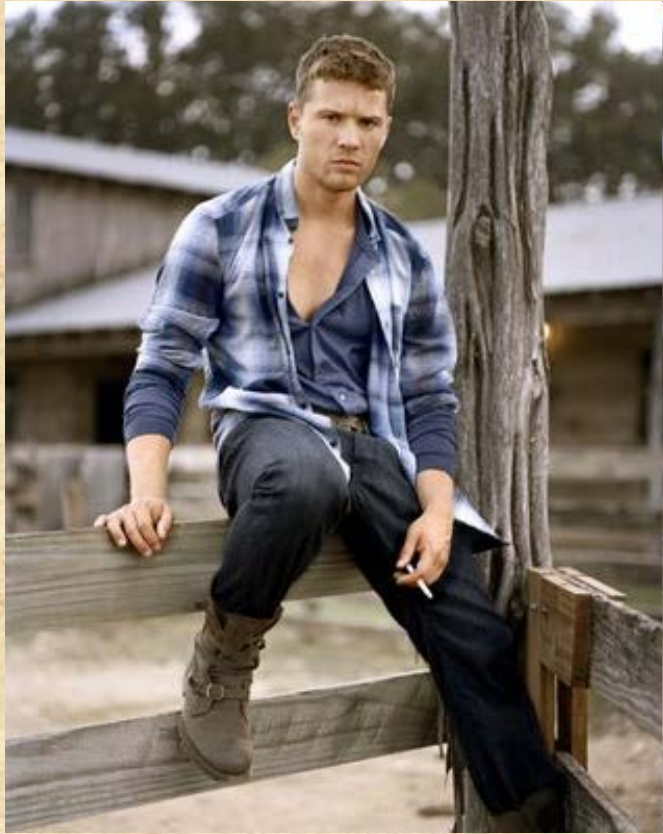
Meet Farmer Dave



Dave Owns 17 Cows



Farmer Dave Has Three Sons



Dave's Not Looking Healthy!



He Wills 17 Cows to His Sons

- $\frac{1}{2}$ to eldest
- $\frac{1}{3}$ to middle
- $\frac{1}{9}$ to youngest



It Doesn't Work – Tempers Rise!

- $17/2 = 8.5$
- $17/3 = 5.7$
- $17/9 = 1.9$



Neighbor Pam Hears the Ruckus

- “I can fix this”
- Goes to her farm
- “You can have my biggest cow”



They Do The Math

- $18/2 = 9$
- $18/3 = 6$
- $18/9 = 2$
- 17 cows
- Everybody's happy
- Pam takes her cow home



Be Careful of Initial Assumptions

- Ask questions before handling
- Do you have any lab chemicals?
- Anything weird I should know about?
- Did you combine chemicals together?



Familiarity Breeds Contempt

- Don't be chemically complacent



So, keep an eye out for each other
Stay alert – Have fun out there



Let's take a 5 minute break –
then Jeffry Dade will take over

