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PHARMACEUTICAL INORGANIC CHEMISTRY: Antimicrobial's

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PREPARATION AND EVALUATION OF NANODOSAGE FORMS OF SELECTED NON-STEROIDAL ANTI-INFLAMMATORY DRUGS AND ITS MANAGEMENT IN ORAL AND COLORECTAL CANCERS [View project](#)

Antimicrobials: Mechanism, classification, Potassium permanganate, Boric acid, Hydrogen peroxide*, Chlorinated lime*, Iodine and its preparations

- An antimicrobial is an agent that kills microorganisms or stops their growth.
- The most common targets for antimicrobial drug actions fall into 5 basic categories:
 - i. Inhibition of Cell Wall Synthesis
 - ii. Inhibition of Protein Synthesis
 - iii. Inhibition of Nucleic Acid Synthesis
 - iv. Effects on cell membrane sterols (antifungal agents)
 - v. Inhibition of unique metabolic steps
- **Control of Microbial Growth:**
 - **Sterilizing Agents:**
 - **Disinfectants:** Disinfectants are antimicrobial agents that are applied to the surface of non-living objects to destroy microorganisms that are living on the objects. Disinfection does not necessarily kill all microorganisms, especially resistant bacterial spores; it is less effective than sterilization.
 - **Antiseptics:** Antiseptic(s) (from Greek anti: "against" and sēptikos: "putrefactive") are antimicrobial substances that are applied to living tissue/skin to reduce the possibility of infection, sepsis, or putrefaction.
 - **Chemotherapeutics:** The chemical agents which is used in the clinical application of antimicrobial agents to treat infectious disease.
- **Medicines with an antimicrobial activity are divided into two groups:**
 - i. Non-selective antimicrobial agents, causes most destructive effect on the majority of microorganisms (antiseptics and disinfectants).
 - ii. Selective antimicrobial drugs (chemotherapeutic agents)
- **Requirements for antiseptics and disinfectants**
 - Must have a broad spectrum of action;
 - Rapid onset of action;
 - Should have a small latency period;
 - Should have a high activity;
 - Must be chemically resistant;
 - High availability and low cost;
 - Lack of local irritant or allergic effects on tissues;
 - Minimal absorption from the place of their application;
 - Low toxicity.
- **Classification of Antiseptics and Disinfectants (according chemical structure)**



1. Inorganic substances

(i) Halogens	(ii) Oxidizing agents	(iii) Acids and alkalis	(iv) Metallic salts
○ Iodine (2%, 3%, 5% alcohol solution)	○ Hydrogen peroxide	○ Boric acid	○ Silver nitrate
○ Povidon-Iodine	○ Potassium permanganate	○ Salicylic acid	○ Copper sulfate
○ Lugol's solution		○ Solution of ammonia	○ Zinc sulfate
○ Chlorhexidine			○ Zinc oxide

2. Organic substances

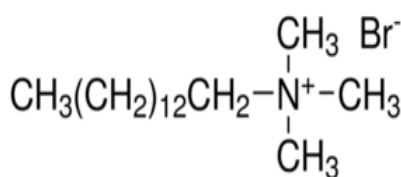
(i) Aldehydes	(ii) Alcohols	(iii) Phenol derivatives	(iv) Dyes
○ Formaldehyde	○ Ethyl alcohol	○ Phenol	○ Methylene blue
○ Glutaraldehyde		○ Cresol	○ Brilliant green
○ Hexamethylenetetraminum		○ Resorcinol	
		○ Thymol	

• **SAVLON ANTISEPTIC (Solution)**

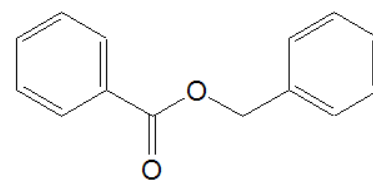
Composition: An aqueous solution containing 0,3 g Chlorhexidine gluconate and 3,0 g Cetrimide as active ingredients per 100 mL and 2,84% m/v n-propyl alcohol and 0,056% m/v Benzyl benzoate as preservatives.



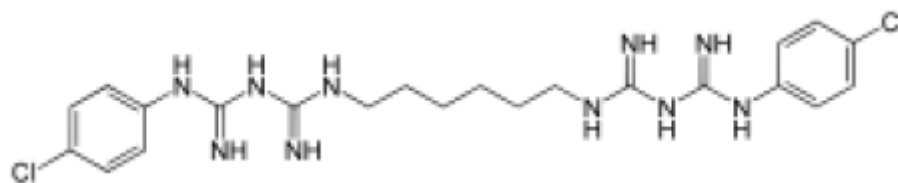
n-propyl alcohol



Cetrimide

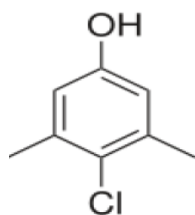


Benzyl benzoate

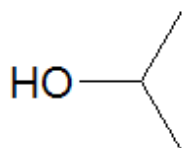


Chlorhexidine

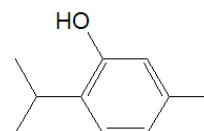
• **Composition of DETTOL:** Chloroxylenol comprises 4.8% of Dettol's total admixture, with the rest made up by pine oil, isopropanol, castor oil, soap and water



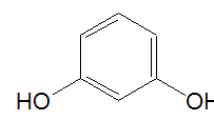
Chloroxylenol,
[also known as para-chloro-meta xylenol (PCMX)]



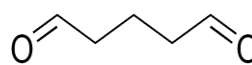
isopropanol



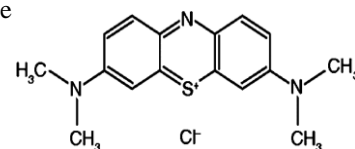
Thymol



Resorcinol

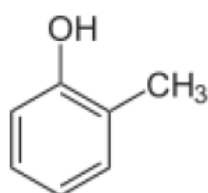


Glutaraldehyde

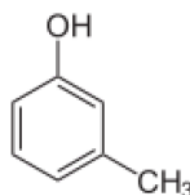


Methylene blue

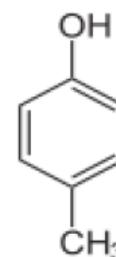
• **CRESOLS** (also hydroxytoluene) are organic compounds which are methyl phenols.



o-cresol



m-cresol



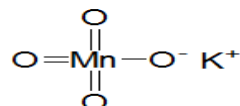
p-cresol

Common name	<i>o</i> -cresol	<i>m</i> -cresol	<i>p</i> -cresol
Systematic name	2-methylphenol	3-methylphenol	4-methylphenol
Other names	ortho-cresol	meta-cresol	para-cresol
Appearance	colorless crystals	thicker liquid	greasy-looking solid
Density	1.05 g/cm ³ (solid)	1.03 g/cm ³ (liquid)	1.02 g/cm ³ (liquid)
Molecular formula		C₇H₈O	

❖ Potassium permanganate

Other names: Condy's crystals; Permanganate of potash; Hypermangan

Chemical formula: KMnO_4 **Molar mass:** 158.034 g/mol



- **Properties**

Appearance: purplish-bronze-gray needles

Odor: odorless

Density: 2.703 g/cm³

Melting point: 240⁰ C

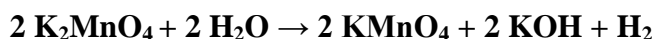
Solubility: Freely soluble in water and alcohol

Refractive index: 1.59

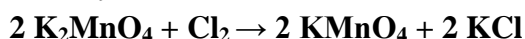
Taste: Better with metallic taste

- **Preparation**

- **Industrially Method:** The MnO_2 is fused with potassium hydroxide and heated in air.



- Potassium manganate can be oxidized by chlorine



- Potassium manganate when treated with Hydrochloric acid

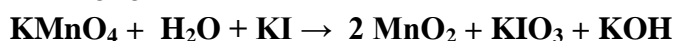


- Potassium manganate when treated with Carbon dioxide

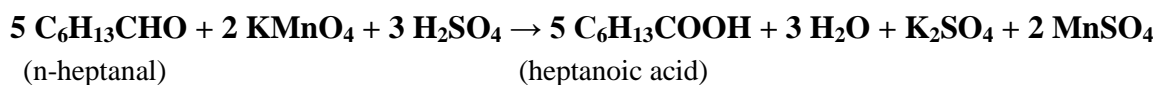


- **Reaction**

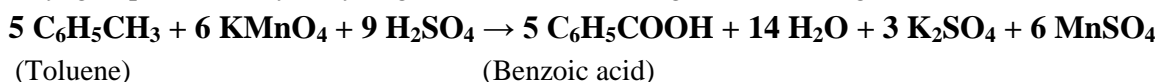
- Potassium acts as strong oxidizing agents



- Potassium permanganate oxidizes aldehydes to carboxylic acids



- Even an alkyl group (with benzylic hydrogen) on an aromatic ring is oxidized, e.g. toluene to benzoic acid.



- Solid potassium permanganate decomposes when heated: $2\text{KMnO}_4 \rightarrow \text{K}_2\text{MnO}_4 + \text{MnO}_2(s) + \text{O}_2$

- **Uses**

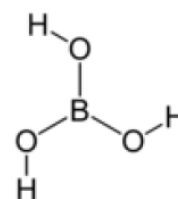
- Due to its strong oxidising properties it is used as disinfectant and deodorant.
- It is also used as astringents, anti-infective and bactericidal.
- 1-5% hydroalcoholic solution of potassium permanganate used as wet dressing.
- Potassium permanganate has been used in attempts to induce abortions at home. But it is legal restrictions on the chemical in response to its use as an abortifacient.
- Potassium permanganate was used as a bleaching agent.
- Potassium permanganate is used extensively in the water treatment.

- **Storage:** Store in well closed container and kept in a cool place

❖ Boric acid

Synonym : Hydrogen borate, Boracic acid, Orthoboric acid, Acidum boricum

Chemical formula : H_3BO_3 or BH_3O_3 or $\text{B}(\text{OH})_3$ **Mol. Weight** : 61.83 g/mol



• Physical Properties

Appearance : White crystalline solid or granular

Density : 1.435 g/cm³

Melting point : 170.9 °C **Odor** : Odorless **Tasteless** : Sweetish after taste

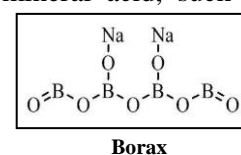
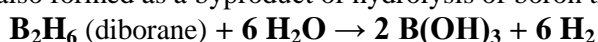
Solubility : Sparingly soluble in water [2.52 g/100 mL (0°C); 5.7 g/100 mL (25°C); 27.53 g/100 mL (100°C)]
Freely soluble glycerine; Slightly soluble in Alcohol.

• Preparation

- Boric acid may be prepared by reacting borax (sodium tetraborate decahydrate) with a mineral acid, such as hydrochloric acid:

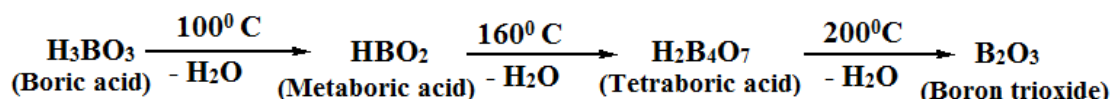


- It is also formed as a byproduct of hydrolysis of boron trihalides and diborane:

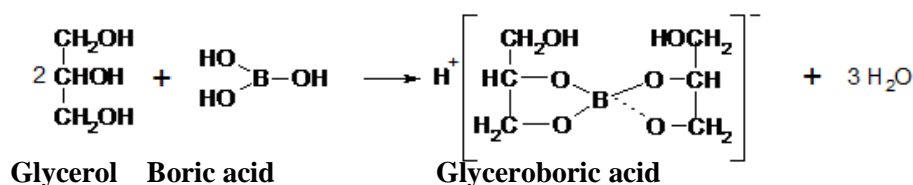
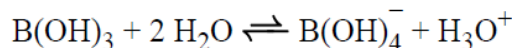


• Reaction

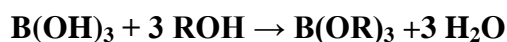
- Boric acid is soluble in boiling water. When heated above 100°C, it dehydrates, forming *metaboric acid* (HBO_2) and when *metaboric acid* heated at 160°C it converted into *tetraboric acid* or *pyroboric acid* ($\text{H}_2\text{B}_4\text{O}_7$) and when *pyroboric acid* is heated above 200°C it decompose into *boron trioxide* (B_2O_3):



- Boric acid is weak acid but when boric acid dissolve in glycerin it gives glyceroboric acid and has ionization constant is 10,000 times greater than that of boric acid.



- Boric acid reacts with alcohols to form borate esters $[\text{B}(\text{OR})_3]$ where **R** is alkyl or aryl.



• Uses

- Boric acid can be used as an antiseptic for minor burns or cuts. it is also used as weak bacteriostatic, fungistatic and astringents.
- Boric acid is applied in a very dilute solution as an eye wash.
- Dilute boric acid can be used as a vaginal douche to treat bacterial vaginosis due to excessive alkalinity.
- It is also used as mouth washes, skin lotion for local anti-infective action.
- Its use as an insecticide.
- The boric acid-borate system can be useful as a primary buffer system.
- Boric acid is used in some nuclear power plants as a neutron poison. The boron in boric acid reduces the probability of thermal fission by absorbing some thermal neutrons.
- It is also used in preservation of grains such as rice and wheat.

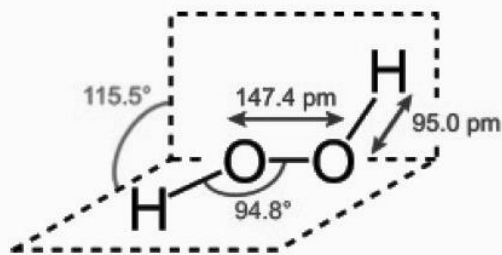
• **Storage:** Store in well closed container and kept in a cool place.

• **Adverse effect:** Vomiting, abdominal cramps.

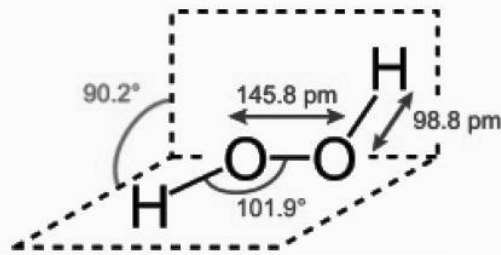
❖ Hydrogen peroxide

Synonym : Dioxidane; Oxidanyl; Perhydroxic acid **Chemical formula** : H_2O_2 **Mol. Weight** : 34 g/mol

- Hydrogen peroxide (H_2O_2) is a nonplanar molecule with twisted symmetry. Although the O–O bond is a single bond, the molecule has a relatively high rotational barrier.
- The molecular structures of gaseous and crystalline H_2O_2 are significantly different. This difference is attributed to the effects of hydrogen bonding, which is absent in the gaseous state.



Structure and dimensions of H_2O_2 in the gas phase

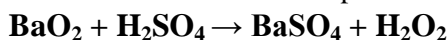


Structure and dimensions of H_2O_2 in the solid (crystalline) phase

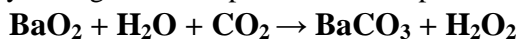
• Preparation:

1. From Barium peroxide

- When aqueous cream of barium peroxide treated with cold dilute sulphuric acid forms hydrogen peroxide:

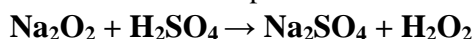


- When carbon dioxide is passed slowly through ice-cold paste of barium peroxide, then hydrogen peroxide produced:



2. From Sodium Peroxide:

- Sodium peroxide decomposed by addition of cold dilute sulphuric acid forms hydrogen peroxide:



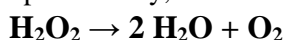
• Physical Properties:

Colour : Clear colourless liquid; **Odour** : Odorless; **Taste** : Bitter; **Density** : 1.145 g/cm³ (20°C, pure)

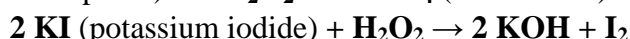
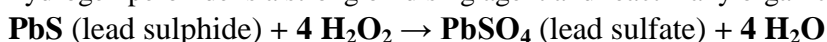
Boiling point : 150.2°C; **Solubility in water** : Miscible; **Acidity (pKa)** : 11.75 (slightly acidic)

• Chemical Properties:

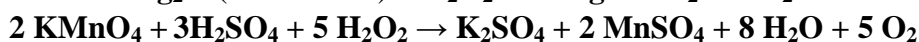
- Decomposition:** Pure hydrogen peroxide decompose slowly, but when heated at 100°C it liberate oxygen:



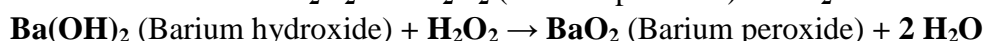
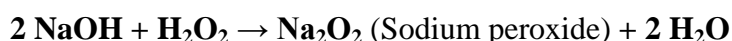
- Oxidation properties:** Hydrogen peroxide is a strong oxidising agent and react many organic materials.



- Reduction properties:** Hydrogen peroxide behaves as reducing agents towards other oxidizing agents.



- Acidic in nature:** Hydrogen peroxide is slightly acidic in nature through in dilute solution it is neutral towards litmus.



• Assay of Hydrogen peroxide:

- Assay of hydrogen peroxide depend on the oxidation-reduction titration.
- 10 ml the H_2O_2 is diluted with 10 ml distilled water, then add 10 ml of 5N Sulphuric acid and then titrated with 0.1N potassium permanganate solution, until a faint pink color is obtained.
- Each ml of 0.1N KMnO_4 = 0.001701 g of H_2O_2



- **Uses:**

- **Medical uses:**

- Hydrogen peroxide used as an antiseptic, germicidal and disinfectant.
 - Hydrogen peroxide can be used for the sterilization of various surfaces, including surgical tools and may be deployed as a vapour (VHP) for room sterilization.
 - H_2O_2 demonstrates broad-spectrum efficacy against viruses, bacteria, yeasts, and bacterial spores. In general, greater activity is seen against Gram-positive than Gram-negative bacteria.
 - Hydrogen peroxide was used for disinfecting wounds.

- **Cosmetic applications**

- Diluted H_2O_2 (between 1.9% and 12%) mixed with ammonium hydroxide is used to bleach human hair.
 - Hydrogen peroxide is also used for tooth whitening. It can be found in most whitening toothpastes.
 - Hydrogen peroxide may be used to treat acne.

- **Propellant**

- High-concentration H_2O_2 is referred to as "high-test peroxide" (HTP). It can be used either as a monopropellant (not mixed with fuel) or as the oxidizer component of a bipropellant rocket.

- **Explosives**

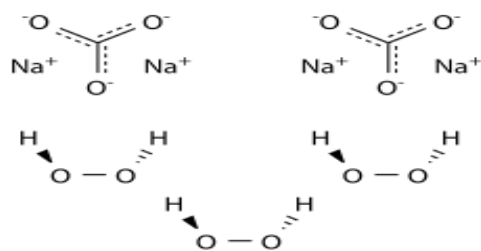
- Hydrogen peroxide has been used for creating organic peroxide-based explosives, such as acetone peroxide, for improvised explosive devices.

- **Industrial**

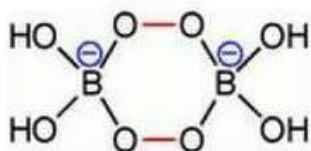
- About 60% of the world's production of hydrogen peroxide is used for pulp and paper-bleaching.
 - The second major industrial application is the manufacture of **sodium percarbonate** and **sodium perborate** which are used as mild bleaches in laundry detergents.

- **Storage:** Store in cool & dark place and light resistant container.

SODIUM PERCARBONATE is an adduct of sodium carbonate and hydrogen peroxide, with formula $2\text{Na}_2\text{CO}_3 \cdot 3\text{H}_2\text{O}_2$. As an oxidizing agent, sodium percarbonate is an ingredient in a number of home and laundry cleaning products



SODIUM PERBORATE (PBS) is a white, odorless, water-soluble chemical compound with the chemical formula $\text{Na}_2\text{B}_2\text{O}_4(\text{OH})_4$. This salt is widely used in laundry detergents.



Chlorinated lime

Bleaching powder is not a simple mixture of calcium hypochlorite, calcium chloride, and calcium hydroxide. Instead, it is a mixture consisting principally of **calcium hypochlorite** [Ca(OCl)_2], **dibasic calcium hypochlorite** [$\text{Ca}_3(\text{OCl})_2(\text{OH})_4$], and **dibasic calcium chloride** [$\text{Ca}_3\text{Cl}_2(\text{OH})_4$]. It is made from slightly moist slaked lime.

Synonym: Hypochlorous acid; Bleaching powder; Calcium oxychloride; Calcium hypochlorite

Mol. Formula: Ca(OCl)_2 **Mol. Weight:** 142.98 g/mol

Appearance: White/gray powder

Density: 2.35 g/cm³ (20°C)

Melting point: 100°C

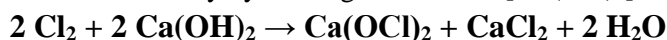
Solubility in water: 21 g/100 mL

Odour: It has strong odour of chlorine

Note By: on exposure to air it becomes moist and rapidly decomposes to release Hypochlorous acid.

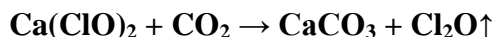
Preparation:

- Calcium hypochlorite is produced industrially by treating slaked lime [Ca(OH)_2] with chlorine gas.

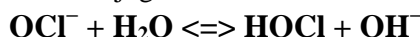


Reaction:

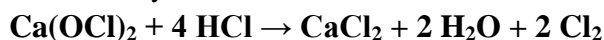
- Calcium hypochlorite reacts with **carbon dioxide** to form calcium carbonate and release **dichlorine monoxide**:



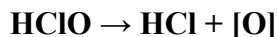
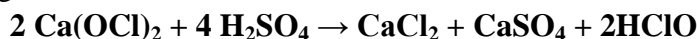
- A calcium hypochlorite solution is basic. This basicity is due to the hydrolysis performed by the hypochlorite ion, as Hypochlorous acid is weak, but calcium hydroxide is a strong base. As a result, the hypochlorite ion is a strong conjugate base, and the calcium ion is a weak conjugate acid:



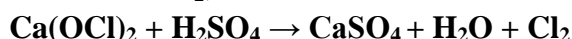
- Similarly, calcium hypochlorite reacts with hydrochloric acid to form calcium chloride, water and chlorine:



- Treatment of chlorinated lime with dilute sulphuric acids liberates Hypochlorous acid which behaves as oxidising and bleaching agents.



- On treatment with excess of dilute acid or CO_2 , the whole of chlorine is liberated:



Uses:

• Sanitation

- Calcium hypochlorite has rapid bactericidal action. It kills most of bacteria, some fungi, yeast, algae, viruses and protozoa.
- Calcium hypochlorite is commonly used to sanitize public swimming pools and disinfect drinking water.
- Calcium hypochlorite is also used in kitchens to disinfect surfaces and equipment.
- Other common uses include bathroom cleansers, household disinfectant sprays, algacides, herbicides, and laundry detergents.

• Organic chemistry

- Calcium hypochlorite is a general oxidizing agent and therefore finds some use in organic chemistry. For instance the compound is used to cleave **glycols**, **α -hydroxy carboxylic acids** and keto acids to yield fragmented **aldehydes** or **carboxylic acids**. Calcium hypochlorite can also be used in the halo form reaction to manufacture chloroform.



Storage:

- Calcium hypochlorite is stored dry and cold, away from any organic material and metals. The hydrated form is safer to handle.