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Phenol-An effective antibacterial Agent

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Research Article

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ABSTRACT

Phenol displays effective antimicrobial activity in-vitro against a wide range of organisms such as bacteria (both gram positive and gram negative), yeasts and molds [1-5]. Phenols combine with nuclear receptors involved in growth and adipogenesis maintainance. Few reports have explored their effects on growth in humans. Phenolic substituents are employed in variety of daily products such as cosmetics(parabens), antibacterial soaps(triclosan) and polycarbonate plastics or epoxy resins used in can linings [6-10]. Phenolic compounds are used as antibacterials which include pure form of phenol and by products with halogenos and alkyl groups. They act by denaturing and coagulating proteins.

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INTRODUCTION

Phenol (carbolic acid) is one amongst the oldest antibacterial agents. It acts as a bacteriostat by inhibiting biological process of bacteria at concentrations of 0.1%-1% and is fungicidal in action at concentration of 1%–2%. 5% concentration kills anthrax spores in 48 hours. The antiseptic activity is increased by EDTA and heat temperatures; it's decreased by alkaline medium (through ionization), lipids, soaps, and cool temperatures[11-20].Concentrations >0.5% exert an localised anesthetic result, whereas 5% solution is powerfully allergic and burns to tissues. Oral consumption or in mixing up with skin will cause general toxicity, mainly affecting systema nervosum centrale and vessel effects; and might result in death [21-25]. Phenol has sensible penetration power into organic content and is principally used for medical aid of apparatus or organic content that square measure to be eliminated (eg, infected food and excreta). Owing to its irritant action and caustic properties and capable general toxicity, it's not used very much like an antibacterial presently, except to treat infected areas, eg, the infectious omphalos of neonates. It is additionally incorporated into cutaneal applications for itching, stings, bites, burns, etc, owing to its anesthetic action and antibacterial activity to alleviate itching and helps to manage infections [26-30].

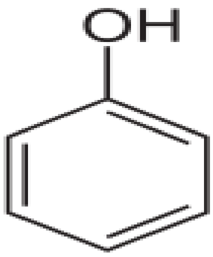
NATURAL SOURCES OF PHENOLS

Phenols are derived commonly in nature; examples embrace aminoalkanoic acid, one in all the quality amino blocks found in many proteins; vasoconstrictive (such as adrenaline), a stimulant endocrine originating from adrenal medulla; monoamine neurotransmitter [31-35], a neurochemical within the brain; and urushiol, associate pain secreted by poison Hedera helix to forestall animals from uptake its leaves. Several of the additional advanced type of phenols used as flavouring agents and aromas square measure extracted from essential oils coming from plants. Parenthetically, vanillin, the principal flavoring in vanilla, is obtained from vanilla beans, and sweet-birch oil, that includes a unusual minty taste and odour, is extracted from wintergreen. Different types of phenols obtained from plants embrace phenol [36-40], isolated from thyme, and eugenol is obtained from cloves Figure 1.

Figure 1: Poison ivy (*Toxicodendron radicans*) is a natural source of the phenol …
Walter Chandoha

CHEMISTRY OF PHENOL

1) ***IUPAC Name:*** Phenol
2) ***Other names:*** Benzenol,Carbolic acid,Phenylic acid,Hydroxybenzene,Phenic acid
3) ***Chemical Formula:*** C_6H_6O
4) ***Molecular mass:*** 94.11 g•mol−1
5) ***Appearance:*** Transparent crystalline solid
6) ***Odor:*** Sweet and tarry
7) ***Melting Point:*** 40.5 °C (104.9 °F; 313.6 K)
8) ***Boiling Point:*** 181.7 °C (359.1 °F; 454.8 K)
9) ***Structure:***



10) ***Solubility:*** Soluble in water and the Na^+salt form of phenol is more soluble in phenol

Phenol is weakly acidic and at high pHs gives the phenolate anion C6H5O− (also called phenoxide) [41-45]:

PhOH ⇌ PhO− + H+ (K = 10−10)

Compared to aliphatic alcohols, phenol is about 1 million times more acidic, although it is still considered a weak acid. It reacts completely with aqueous NaOH to lose H+ [46-50], whereas most alcohols react only partially **Figure 2.**

Figure 2: Solid form of phenol

PHENOL COMPOUNDS

a) **Cresol (cresylic acid)** could be a mixture of ortho-, meta-, and paracresols and their isomers. It is a colorless liquid; but, exposure to light and air, it turns pink, then chromatic, and at last dark brown. A two hundredth resolution of either pure or saponated phenol "lysol" in plight is often used as a disinfectant for inanimate objects [51-55].

b) **Hexachlorophene (a trichlorinated bis-phenol)** incorporates a robust organic process action against several gram-positive organisms (including staphylococci) however solely some gram-negative ones. It is used widely in medicated soaps. Frequent washings on a daily basis with antibacterial soaps result in adequate retention of residue on the skin to supply prolonged organic process action. The laundry with alternative soaps promptly removes these residues [56-58]. Continuous exposure of skin to high concentrations of antibacterial might result in adequate absorption of the antiseptic to cause spongiform degeneration of the substantia alba within the brain, cerebral dropsy, and nervous disorders. To stop such neurotoxicity, merchandise containing >0.75% antibacterial are given on prescription. Accidental oral intake of antibacterial ends up in acute poisoning [59,60].

c) **Pine tar** is a viscid blackish brown liquid, used primarily for antiseptic bandaging of wounds of the hoof and horn. Pine tar contains phenol derivatives that provide antimicrobial properties.

d) **Chloroxylenols** square measure broad-spectrum bactericides with a lot of activity against gram-positive than gram-negative bacterium. They are active in basic pH [61-64]; but when in contact with organic matter diminishes their activity. Streptococci show a lot of vulnerability than staphylococci to these agents.

e) **Parachlorometaxylenol** (PCMX) and **dichlorometaxylenol** (DCMX) area the two most ordinarily used members of this cluster. DCMX is a lot of active than PCMX. Robust solutions of those compounds will cause irritation and have a disagreeable odor [65-70]. A 5% of chloroxylenol (eg, PCMX) (in α-terpineol, soap, alcohol, and water) is diluted with water (1:4) for skin sterilization and (1:25 to 1:50) for wound cleansing and irrigation of the womb and duct. PCMX is additionally combined with bactericide to boost its antibacterial drug spectrum and to forestall contamination by gram-negative organisms.

Exposure to phenol could occur from the utilization of some medicative product (including throat lozenges and ointments). Phenol is extremely irritating to the skin, eyes, and secretion membranes in humans when acute (short-term) inhalation or dermal exposures. Phenol is taken into account to be quite venomous to humans via oral exposure [71,72,73]. Anorexia, progressive weight loss, diarrhea, vertigo, salivation, a dark coloration of the excretion, and blood and liver effects are rumored in inveterately (long-term) exposed humans. Animal studies have rumored reduced craniate body weights, growth retardation, and abnormal development within the offspring of animals exposed to phenol by the oral route. EPA has classified phenol as a bunch D, not distinctive on human carcinogenicity [74].

Mechanism of action

Phenol will act on microorganisms in 2 totally different ways: growth inhibition (bacteriostasis, fungistasis) or fatal action (bactericidal, agent or viricidal effects).Only the fatal effects are of interest in medical aid and, because the objects of treatment have no inherent means that of defence, deadliness is that the desired objective [75,76,77]. Although microbiologists are operating for more than a century on the problems related to medical aid, understanding of the mode of action of active molecules remains vague: varied hypotheses exist however few certainties. Several authorshave long maintained that phenols act in a non-specific manner, in contrast to antibiotics that have distinct cellular targets inside the organism. Although several studies still ought to be performed during this field, it's clear that thisdistinction can't be created for a few molecules[78-80]. Phenols are sometimes complicated formulations of active molecules,sometimes additionally containing co-solvents, chelating agents, acidic or alkalic agents, or surface-active or anti-corrosive product. In an analysis of the action of aphenol, it may often be difficult to distinguish between the primary stage (characteristic of the mode of action) and the secondary stage (merely a consequence of the action).

1) Action on the external membrane of the bacterial wall

A bacteria is protected against its surrounding by a membrane, the integrity of that is essential for survival of the bacteria. This membrane consists of basic compounds such as phospholipids and lipopolysaccharides, and is made stable by Mg + + and Ca + +cations. Thus, if ionizing disinfecting molecules are absorbed or repelled by electrical charges at the initial contact and absorption stage, the subsequent means that of action can theoretically be possible [81-83]:

- non-polar molecules could dissolve and enter the supermolecule part
- specific carrying systems can lead different molecules through the membrane
- different molecules are going to be ready to disturb the organisation of the membrane by remaining certain to bound sites.

2. *Action on the bacterial wall*

The bacterial wall is important, as this provides rigidity and differs considerably between Gram-positive and Gram-negative bacteria. This diversity leads to great variation in the response of the hydrophilic antibacterials.

3. *Action on the cytoplasmic membrane*

An active molecule of phenol, may penetrate the cytoplasmic membrane in the following ways [84,85]:

a) passive diffusion which is non-specific and slow
b) active transport which is specific, enabling the accumulation of products in bacteria after either transformation or binding to a membrane protein.

4. Action on the cytoplasm and nucleus

The phenol mechanism may operate on the cytoplasm and nucleus at the chromosome level.

5. Action on bacterial spores

The solidity and also the presence of dipicolinic acid in microorganism spores build these forms far more tough against antibacterials than vegetative forms [86,87]. The active disinfectant phenols embrace extremely oxidising merchandise, akin to oxide and gas, which can destabilise this structure in spores.

USES OF PHENOL

- Approximately two-third of the entire phenol made worldwide is employed to arrange reagents utilized in plastic producing industries. Most of the items around US ar either made of plastics or have plastic parts in them. The condensation reaction of phenol with ketone produces bisphenol that is extensively utilized in chemical compound industries to synthesis numerous epoxide resins and polycarbonates [88,89].
- The chemical action reaction of phenol with aldehyde is employed to commercially prepare phenoplast resins. The ensuing organic compound is thought as phenol –formaldehyde organic compound, commercially it's marketed by the name of Bakelite. Bakelite is extensively employed in electrical switches and vehicles thanks to its property of withstanding extreme conditions of warmth and resistance to electricity and alternative chemicals. The intermediate created throughout the chemical action reaction is termed novolac, this can be an organic compound and is employed as a binding agent or adhesive in several industries. Novolac is additionally used for protecting coating functions [90,91,92].
- Phenol is additionally utilized in the study and extraction of bio-molecules. biological science finds application of phenol within the extraction of nucleic acids from tissue samples for more investigations.

- Phenol is also used in cosmetic industry in the manufacturing of sunscreens, skin lightening creams and hair coloring solutions.
- Used to turn out epoxy resins for paints coatings and mouldings, and in polycarbonate plastics, acquainted in CDs and domestic electrical appliances.
- Caprolactam is employed within the manufacture of nylon and polymer plastics for a good vary of product, together with carpets, clothing, fishing nets, moulded elements and packaging [93,94].
- Intermediate of phenol is employed as associate inhibitor in rubber manufacture, associated as an intermediate in herbicides, dyes and pigments, and pharmaceuticalsIt is employed to form isocyanates for the assembly of polyurethanes, with a good vary of uses from paints and adhesives to enlarged foam cushions.
- These compounds are employed in the manufacture of surfactants, detergents and emulsifiers, and additionally in insect powder and plastics production.
- Used in medical antiseptics and bactericides admire transmission control protocol and Dettol. Additionally employed in fungicides for timber preservation and as additives to inhibit microorganism growth in several products; accustomed manufacture a variety of pesticides.
- This is employed in the assembly of analgesic and alternative prescription drugs [95-99].

CONCLUSION

In conclusion, there's associate imperative have to be compelled to investigate a lot of the character of the repressive and fatal effects of phenols as antibacterial agents on a variety of microorganisms and microbic entities. The doable multiple target sites and concentration-dependent effects would type a crucial side of such studies, which might additionally give an improved understanding of intrinsic properties and show microorganism resistance mechanisms and of the doable linkage between biocide usage and antibiotic resistance.

Although the notion of a target within the microorganism cell is usually elicited within the case of phenols, this side remains rather obscure with respect to antibacterial. Nor can antibacterial action be thought-about specific to a selected microorganism species, whereas such specificity is common in antibiotics. However, this clearly masks an explicit disparity involving variations in activity between gram-positive and gram-negative bacteria. One should conjointly bear in mind the principal parameters that condition the action and therefore the effectualness of phenols (e.g. temperature, pH, concentration, time of contact).

The potential conjugated result of many antibacterials conjointly deserves reflection. Again,as the modes of action don't seem to be invariably well outlined, it's troublesome to talk of a synergisticeffect. At most, an additive result is exerted once the concentrations of the active ingredients square measure fittingly custom-made. Due to the comparatively scant information of modes of action, and therefore the existence of complicated formulations, product from two completely different manufacturers mustn't be mixed, seeable of the potential antagonistic effects ofdifferent product. Brief mention should be created here of microbic resistance to antibacterials, which hasno parallel with resistance to antibiotics. Makers at the agricultural and food industries usually claim that the microorganism on their premises became immune to the product used as antibacterial. Very little is thought of the microbic ecology of productionunits in these industries, as analysis during this field isn't systematized. Nonetheless, various studies have shown that bound microorganism become immune to element following chlorination treatment of water.

Future analysis ought to focus on discerning the mode of action of antibacterials on viable microorganism, microorganism beneath stress and microorganism components of a biofilm, beneath the conventional conditions of use.Under such conditions it'll clearly be troublesome to get a 99% reduction in the microorganism gift, pro re nata by the standards of the Association française Delaware normalisation (French Standardisation Association).
Cleaning and medical aid should be absolutely effective, limiting contamination to an acceptable minimum level that is compatible with any manufacture.

In recent years, rotation of phenols as disinfectants in hospitals e.g. within the pharmaceutical and food industries, has been advocated to stop the event of microorganism resistance. It has been claimed that, ideally, one disinfectant ought to get replaced by another having a dissimilar mechanism of action.

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