ROLE OF QUATERNARY AMMONIUM COMPOUNDS CONTAINING DISINFECTANTS IN INDUSTRIAL DISINFECTION: A REVIEW

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Abstract: Quaternary ammonium compounds like Benzalkonium chloride (BAC) and Didecyldimethylammonium chloride (DDAC) serve as an exceptional antimicrobial agent and hence are widely used in the formulations of disinfectants for effective actions. These quaternary ammonium compounds have excellent activity against bacteria, fungi, viruses and endospores. Polyhexamethylene biguanide (PHMB) being a polymer serves as a disinfectant and antiseptic. This exceptional feature of BACs, DDACs & PHMB makes them a vital kind of disinfectant combination which can be effectively used in various industries. This article primarily aims at the uses of industrially available disinfectants containing QACs in various fields.

Keywords: **Benzalkonium chloride, Didecyldimethylammonium chloride, Polyhexamethylene biguanide, Disinfectant, Applications.**

I. INTRODUCTION

A class of quaternary ammonium compounds (QACs) which are commonly known as Quats are salts of quaternary ammonium cations. These quaternary ammonium compounds are generally prepared with the help of the process of alkylation of tertiary amines with a halocarbon. The reaction of quaternization results in the production of compounds containing unequal alkyl chain lengths. QACs especially those containing long alkyl chains exhibits exceptional disinfectant properties and at the same time it can also acts as an effective antimicrobial agents as they are very effective against bacteria, yeasts, molds and virus. QACs like Benzalkonium chloride (BAC), benzethonium chloride, methylbenzethonium chloride, cetrimonium, cetrimide, cetalkonium chloride and didecyldimethylammonium chloride (DDAC) are generally used as effective antimicrobials & disinfectants. Polyhexamethylene biguanide (PHMB) containing disinfectant solutions are commonly used for the pre- and post-surgery skin and mucous membrane disinfection, surgical and non-surgical wound dressings and post-operative dressings. These disinfectant solutions are also used in surgical bath, OT/HOSPITAL Surface disinfection and for effective routine antisepsis during minor incisions, catheterization, etc. (Tezel, U. and Pavlostathis, S.T., 2012).

The mode of action of most QACs, including BACs involves the process of perturbation that results in the disruption of the membrane bilayers by the alkyl chains and disruption of charge distribution of the membrane by the charged nitrogen. This results in the progressive leakage of cytoplasmic components out of the cell and finally cell lysis. Nowadays, various types of disinfectant products having components like Benzalkonium chloride, Didecyldimethylammonium chloride (DDAC) are commonly used as extremely useful biocides in a wide range of applications. Advantages of using disinfectants containing Benzalkonium chloride includes ability of fast acting biocidal properties with a moderately long duration of action along with an excellent efficacy against bacteria, fungi, protozoa and viruses. The activity of disinfectants containing Benzalkonium chloride as an active ingredient also possesses wider range of pH and in presence of higher temperature and prolonged exposure times the overall activity of BAC containing disinfectants is more (Beatriz, M. and Ilias T., 2019).

Disinfectants containing combination of QACs like Benzalkonium chloride (BAC) & Didecyldimethylammonium chloride (DDAC) play a crucial role in controlling the bioburden in various areas like laboratories, manufacturing area, sterile rooms, clean rooms, operation theatres etc. Since many disinfectants contain comparatively poor cleaning ability and thus not easily able to penetrate soiled materials, and hence these soiled surfaces must be rinsed frequently with the help of detergent prior to use of disinfection. These disinfectants work more efficiently when used in combination with detergents. These disinfectants should be compatible with detergents which are used to achieve maximum cleaning efficacy results (Beatriz, M. and Ilias T., 2019).

The main rationale of this review article is to summarize the different areas of applications where disinfectants containing quaternary ammonium compounds like Benzalkonium chloride & Didecyldimethylammonium chloride in combination with Polyhexamethylene biguanide can be effectively used for the cleaning and disinfection purpose.

Medical & Pharmaceutical Industry:

Aldehyde free surface disinfectant containing quaternary ammonium compounds like Benzalkonium chloride, Didecyldimethylammonium chloride in combination with Polyhexamethylene biguanide (PHMB) serves as an excellent choice of disinfectant as far as medical & pharmaceutical industries are concerned. In medical industry, disinfectant having QACs like BAC & DDAC along with PHMB can be effectively used as a high level surface and aerial disinfectant for hospital use. Different types of surfaces available in hospital area like floors, walls, operation tables, beds, operation trolleys, chairs, overhead lights and other machines appliances can be disinfected with the help of QACs containing disinfectants. These QACs containing disinfectants in combination with Polyhexamethylene biguanide also plays a vital role in the disinfection of critical areas in hospitals such as operation rooms, Intensive Care Unit (ICU), Intensive Coronary Care Unit (ICCU), Neonatal Intensive Care Unit (NICU), etc.

Along with disinfection of these hospital areas, quaternary ammonium compounds containing disinfectants are also used for the cleaning of hospital laundry materials. Hospital laundries including clothing uniforms (Aprons), bed sheets, pillow covers and curtains are also routinely cleaned & disinfected with the help of QACs containing disinfectant solutions (Price, P., 1950 and Marple, B., 2004).

Disinfectants containing quaternary ammonium compounds have certain advantages like excellent material compatibility with rubber, plastics, fiber glass and other metals makes them the choice of disinfectant for disinfection purposes. QACs are extensively used as bioactive agents. Since they exhibits broad spectrum of antimicrobial activities, they can be effectively used as fungicides, pesticides and hard surface cleansers. These disinfectants possess excellent activities against bacteria, fungi and viruses even when tested at a very low concentration (Shane, H., Lukomska, E., Kashon, M. and Anderson, S., 2019).

Microbiological quality of air in the hospital area nowadays reflects as a mirror of hygienic conditions of any place, especially, operating theatres in hospital area. Aerial disinfection with the help of disinfectant containing quaternary ammonium compounds in combination with Polyhexamethylene biguanide (PHMB) serves as an essential method for better air quality in critical areas. Automatic fogging machines can be effectively used for the aerial disinfection purposes.

Water Treatment Industry:

Quaternary ammonium compound containing disinfectant can be efficiently used in the water and effluent treatment plants for achieving the microbial load in the treated water. These disinfectant solutions can also be used as algaecides in swimming pool. Quaternary ammonium compound containing disinfectants exhibits excellent microbiological properties when tested against not only bacteria but also algae & fungi. Benzalkonium chloride (BAC) helps in the reduction of the requirement of harmful Antibiotics in Aquaculture through improved hygiene. These disinfectants containing BAC were routinely used for the various applications in aquaculture like general site disinfection, removal of fish parasites which also results in the prevention of infectious diseases in fish.

Disinfectants containing quaternary ammonium compounds in combination with Polyhexamethylene biguanide (PHMB) can be effectively used for the process of water treatment in water systems, air conditioning machinery, and cooling towers. Gram negative disease causing bacterium from the genus *Legionella* is also efficiently removed with the help of these disinfectant solutions (Ismail, Z., Tezel, U. and Pavlostathis, S.T., 2010).

Food & Beverage Industry:

Food and beverage industries widely use disinfectants containing quaternary ammonium compounds in combination with Polyhexamethylene biguanide (PHMB) for efficient removal of microorganisms. Equipments functioning in food & beverage industries like pipes, processing and holding tanks along with collection bottles are usually disinfected with the help of these disinfectants solutions. DDAC & BAC are mostly used in the dairy industry for efficient disinfection of all kind of surfaces including milk storage tanks, milking equipments and ice-cream manufacturing machines. These quaternary ammonium compounds also play a key role in the prevention of mastitis and thus help in production of raw milk with low bacterial count.

Benzalkonium chloride possesses certain advantages like non-corrosive and non-toxic characteristics and due to which it can be widely used in cleaning sanitizer formulations. These disinfectant solutions play a crucial role in disinfection of equipments used in fisheries, breweries, slaughter houses and dairy industry. Disinfection of the packaging material with these disinfectant solutions also reduces the chances of contamination by removal contamination causing microorganisms (GordonDunn, C., 1949).

Paper & Pulp Industry:

Paper and pulp industries uses quaternary ammonium compounds like Benzalkonium chloride (BAC) as a general microbicide for slime control applications. Process of odour management also can be performed with the help of solutions containing Benzalkonium chloride. DDAC can also be used as an effective disinfectant agent in textile and pulp and paper industries. These quaternary ammonium compounds containing disinfectants are commonly used to control microbial growth in waters of the paper mill process (Koskela, J., and Hormi, O., 2002).

Veterinary Industry:

In veterinary industry, disinfectant containing quaternary ammonium compounds can be efficiently used for a variety of applications including general surface and equipment disinfection, aerial fogging and treatment of water supply systems. Automatic automist fogging machines are routinely used for disinfection of buildings containing animal housings. Use of these fogging machines also guarantees the disinfection of critical areas which are a bit difficult to access as far as surface disinfection is concerned. Disinfectant solutions containing BAC, DDAC and PHMB can also be efficiently used for the sanitization of water systems in veterinary industry which also ensures cleaning & efficient elimination of bacterial or fungal growth (Bragg, R. et al. 2013).

II. CONCLUSION

Due to very broad spectrum of microbicidal properties quaternary ammonium compounds containing disinfectants along with Polyhexamethylene Biguanide (PHMB) serves as one of the most trusted and desirable choice of disinfectant. These disinfectant combinations can play a crucial role of disinfectant and cleaning agent in various fields like medical, pharmaceutical, food, water treatment, and veterinary industries. The current review article highlighted various industrial applications of disinfectants containing combination of quaternary ammonium compounds like Benzalkonium chloride (BAC), Didecyldimethylammonium chloride (DDAC) & Polyhexamethylene biguanide (PHMB).

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