

DISINFECTANTS AND CORONAVIRUS DISEASE 2019 (COVID-19): A MINI REVIEW

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Abstract: The 2019 novel corona virus (2019-nCoV), now known as coronavirus disease (COVID-19), is a major public health threat, impacting both health of populations and economies worldwide, since its emergence in a city called Wuhan, China in December 2019. Known to be highly infectious via human-to-human transmission, the virus can cause severe respiratory infections, resulting in mortality. Because of the current lack of effective drugs to treat or a vaccine to prevent COVID-19 or the SARS-CoV-2, which causes it, disinfectant use is encouraged at a personal level and especially in healthcare and residential settings to control the spread of the virus. The current knowledge of available disinfectants commonly used, their active ingredients and effectiveness in combating COVID-19 will be discussed in this mini review.

Keywords: Disinfection, active ingredients, virus, COVID-19.

Introduction

The 2019 novel corona virus (2019-nCoV), which is caused by the SARS-CoV-2 virus made its first presence in Wuhan, China in December 2019, causing severe acute respiratory tract infections (Lai *et al.*, 2020; Spagnuolo *et al.*, 2020). Since its emergence, it has spread to other parts of China and also other countries around the world, with an estimation of more than 213 countries, areas or territories and more than 692,694 deaths (as of 3rd August; WHO, 2020). It has led to the declaration of a pandemic by the World Health Organization, WHO (Liu *et al.*, 2020; Lai *et al.*, 2020). The WHO coined a new name for the pandemic disease as coronavirus disease (COVID-19). The SARS-CoV-2 virus, reported to attack the lower respiratory system causing viral pneumonia, is also capable of leading to multiple organ (i.e., liver, kidney, heart and the central nervous system) failures (Liu *et al.*, 2020). More importantly, COVID-19 has impacted the global population economically, emotionally, socially and physically (health). Currently, there are no effective treatments, with considerable efforts been devoted globally to understand its epidemiology and viral properties in order to deliver drugs to treat and a vaccine to combat this virus. Due to lack of a vaccine,

precautionary measures are being stressed to prevent transmissions and infections from human-to-human.

Human-to-human transmission occurs via droplets, contaminated surfaces and also hands (Chakraborty & Maity, 2020; Kampf *et al.*, 2020). Therefore, one of the precautions advocated to control the spread in the general public and also health care facilities is the application of disinfectants and hand sanitizers with frequent hand washing with soap and water. Hand sanitizers or also known as alcohol-based handrubs which contain only ethanol or isopropanol as active ingredients are able to inactivate or kill wide spectrum of microorganisms present on change to hands (WHO 2009; Berardi *et al.*, 2020; Celina *et al.*, 2020). On the other hand, surface disinfectants which typically consist of both active ingredients and low amounts of additional active constituents play a critical role in controlling and eliminating the spread of COVID-19 from animate and inanimate surfaces (Celina *et al.*, 2020; Pradhan *et al.*, 2020). Surface disinfection has been widely accepted as a common practice to decontaminate surfaces and to slow down the spread owing to its practical implementation and reliability in terms of performance (Song *et al.*,

2019). Commonly used active chemical agents or biocides for disinfection are aldehydes, alcohols and chlorine, quaternary ammonium compounds, and peroxygens (Abreu *et al.*, 2013; Song *et al.*, 2019; Kampf *et al.*, 2020). In this mini review, the role and active ingredients for the use of disinfectants for COVID-19 will be presented.

Discussion

Mode of transmission and environmental survival

Various modes of transmission have been identified for COVID-19 (Qu, 2020). The primary mode is human-to-human transmission upon touching infected surfaces which is followed by entry via eyes, nose or mouth. Small droplets from infected individuals (from nose or mouth) may land on any objects or surfaces through cough, sneeze or when exhaling (Peng *et al.*, 2020; WHO, 2020). The current understanding of environmental survival of the SARS-CoV-2 virus shows that it can persist and survive for long hours on various surfaces such as aluminium, latex surgical gloves and sterile sponges. Transmission and its survival via air (particulate matters or dust) remains unclear, due to a lack of scientific data (Peng *et al.*, 2020).

Disinfection process and applications of chemical agents

Efficient cleaning and disinfection are common practices in healthcare facilities to combat microbial presence and transmissions. As cleaning only removes foreign materials from a surface and does not guarantee killing bacteria or

viruses, disinfection is thus applied to eliminate infectious microorganisms (Abreu *et al.*, 2013). Disinfection can be defined as reduction of antimicrobial in terms of a number of viable microorganisms to a specified appropriate level for an intended use or purpose (McDonnell, 2014). Disinfectants can be classified into four categories, namely sterilant, high, intermediate and low-level disinfectants (Table 1) (Abreu *et al.*, 2013; Zhang *et al.*, 2018). The factors that govern the efficiency of a disinfectant include the characteristics of the surface, amount of organic and inorganic matter, pH, temperature, type of infection and the chemical structure of the biocide (Abreu *et al.*, 2013). The mode of action and entry routes depends whether the biocide agent is hydrophilic or hydrophobic in nature. Based on the United States Environmental Protection Agency (EPA) product performance test guidelines, a product should yield an effective log reduction when the bacterial inoculum is suspended in 5% blood serum for a product to be qualified as a cleaner/disinfectant (Boyce, 2018). A list of disinfectants that potentially can be used against SARS-CoV-2 for healthcare, residential and institutional applications has been published by EPA (EPA, 2020). Table 2 shows the selected examples of disinfectants for COVID-19 based on its active ingredients, contact time and surface type. Amongst the active ingredients, quaternary ammonium quaternary ammonium compounds appear to be most commonly used appear to be most commonly used. Hydrogen peroxide, sodium hypochlorite, chlorine dioxide, and hypochlorous acid are also other common active ingredients in the COVID-19 disinfectants list published by EPA.

Table 1: Classification of disinfectants (Abreu *et al.*, 2013; Zhang *et al.*, 2018)

Disinfectant	Action
Sterilant	Able to kill all organisms including bacterial spores
High-level disinfectants	Able to kill all organisms, except high levels of bacterial spores
Intermediate-level disinfectants	Able to kill mycobacteria, vegetative bacteria, most viruses, and most fungi but not necessarily bacterial spores
Low-level disinfectants	Able to kill most vegetative bacteria, spores, some fungi and some viruses

Alcohol-based and active ingredient-based disinfectants

To date, no conclusive evidence is available on the efficient type of biocide for disinfection of surfaces contaminated by SARS-CoV-2. However, existing information suggests that alcohol and alcohol-based disinfectant products are effective in decontaminating inanimate surfaces and the prevention of typical microbial infections, (Boyce, 2018). Table 3 summarises the advantages and disadvantages of commonly used active ingredients in disinfections and the role of these ingredients in disinfectant products varies accordingly.

According to Hsu (2015), the wide usage of alcohol-based hand sanitizers on SARS-CoV-2 is driven by documented activities against bacteria and viruses such as the common influenza virus. Based on IUPAC and common nomenclature, three commonly used alcohols for disinfection in healthcare settings are (1) ethyl alcohol or ethanol, (2) isopropanol or isopropyl alcohol or 2-propanol or propan-2-ol, (3) n-propanol or 1-propanol or propan-1-ol. Alcohol-based disinfectants are effective against fungi, bacteria and viruses and also in the denaturation of protein (Abreu *et al.*, 2013). Quaternary ammonium compounds are basically cationic surfactants or surface-active agents. The basic structure of a quaternary ammonium compound consists of a central nitrogen that is positively charged and commonly attached to four negatively charged anions such as chlorine or bromine (Gerba, 2015). Quaternary ammonium compounds solubilize membrane and cell walls (Abreu *et al.*, 2013). Protein denaturation and removal of biofilms from surfaces can be achieved by peroxygens like hydrogen peroxide and sodium hypochlorite (Lineback *et al.*, 2018). Chlorine-

based products can initiate the oxidation of membrane proteins (Abreu *et al.*, 2013).

Studies which have investigated the efficiency of alcohol-based disinfectants and others against COVID-19 or SARS-CoV-2 are still limited. A study by Kampf *et al.* (2020) investigated the inactivation of human coronaviruses Severe Acute Respiratory Syndrome (SARS) coronavirus, Middle East Respiratory Syndrome (MERS) coronavirus or endemic human coronaviruses (HCoV) by different biocidal agents (ethanol (78%-95%), 2-propanol (70%-100%), the combination of 45% 2-propanol with 30% 1-propanol, glutardialdehyde (0.5%-2.5%), formaldehyde (0.7%-1%) and povidone iodine (0.23%-7.5%)) on different types of inanimate surfaces in hospitals. The study revealed that human coronaviruses could prevail on surfaces such as metal, glass and plastic at room temperature for up to 9 days. Amongst the tested agents, 0.1% sodium hypochlorite and 62%-71% ethanol were recommended for effective surface disinfection of coronavirus within 1 min of exposure, confirming recommendation by WHO to use 70% ethanol for disinfecting small surfaces (WHO, 2009). This is also consistent with WHO's recommendation to adopt alcohol-based hand rubs as the gold standard. The formula recommended by WHO (ethanol [96%] / isopropyl alcohol [99.8%] 833.3 ml; H₂O₂ [3%] 41.7 ml; glycerol [98%] 14.5 ml), which is economical, safe, and culturally and religiously appropriate, is currently accepted for use worldwide. H₂O₂ is incorporated not as an active ingredient, but to eliminate the contaminating spores in bulk solutions and excipients while glycerol is included as a humectant to alleviate, to some extent, the drying effects of alcohol on the skin.

Table 2: Examples of COVID-19 Disinfectants by EPA (2020)

Active ingredients	EPA Registration number	Product name	Contact time (min)	Surface type
Quaternary ammonium	10324-105	Maquat 128-PD	10	Hard Nonporous
	10324-108	Maquat 256-MN	10	Hard Nonporous; Food Contact Post-Rinse Required
	10324-112	Maquat 128-MN	10	Hard Nonporous; Food Contact Post-Rinse Required
	10324-113	Maquat 64-MN	10	Hard Nonporous; Food Contact Post-Rinse Required
	11346-4	Clorox QS	2	Hard Nonporous; Food Contact Post-Rinse Required
Alcohols (Ethanol or ethyl alcohol)	777-136	Lysol Neutra Air® 2 in 1	0.5	Hard Nonporous; Food Contact Post-Rinse Required
	84150-4	Charleston	0.5	Hard Nonporous; Food Contact No Rinse
Hydrogen peroxide; Peroxyacetic acid (Peracetic acid)	10324-214	Maguard 5626	10	Hard Nonporous
	10324-230	Maguard 1522	10	Hard Nonporous
Sodium hypochlorite	1672-67	Austin's A-1 Concentrated Bleach 8.25%	5	Hard Nonporous
	1677-241	Hydris	5	Hard Nonporous
Quaternary ammonium; Isopropanol (Isopropyl alcohol)	10492-5	Discide Ultra Disinfecting Spray	0.5	Hard Nonporous
	46781-6	Cavicide	2	Hard Nonporous

Table 3: The advantages and disadvantages of active ingredients used in disinfectants

Active ingredients	Advantages	Disadvantages	Reference
Alcohol (<i>i.e.</i> ethyl alcohol/ ethanol, isopropanol/ isopropyl alcohol)	Cheap, can be easily obtained, efficient bactericidal effect	Highly flammable, highly volatile	Song <i>et al.</i> , 2019
Quaternary ammonium compounds (<i>i.e.</i> Alkyl dimethyl benzyl ammonium chloride didecyldimethylammonium chloride)	Possess broad biocidal activity (enveloped viruses), attack protein and lipid structures, low toxicity, the most commonly used ingredient in disinfectants	Water hardness affects its activity, biodegradable under aerobic conditions; not active against non-enveloped viruses	Gerba, 2015; McDonnell, 2009; Lineback <i>et al.</i> , 2018; Song <i>et al.</i> , 2019
Peroxygens (<i>i.e.</i> hydrogen peroxide, peroxyacetic acid/peracetic acid etc)	Potent, broad spectrum oxidising agents, aid protein denaturation	Corrosive on medical equipment; discolour metal finishes	McDonnell, 2009; Lineback <i>et al.</i> , 2018; Song <i>et al.</i> , 2019
Chlorine and chlorine compounds (<i>i.e.</i> chlorine dioxide, hypochlorous acid, sodium chlorite, sodium hypochlorite etc)	Effective to remove biofilms from surfaces, requires short exposure time to inhibit growth, cost effective	Corrosive to metals, can be deactivated in the presence of organic matter, formation of carcinogenic compounds	Abreu <i>et al.</i> , 2013; Song <i>et al.</i> , 2019

Conclusion and Future Outlook

Current knowledge shows that SARS-CoV-2 can persist on surfaces from hours to days. Many active ingredients have been included in the formulation of disinfectants but there are no conclusive data on the effectiveness of active ingredients on the SARS-CoV-2 virus. More studies should be performed to investigate the efficacy of the disinfectant products for different contact times, surfaces, settings (e.g., residential, hospitals, businesses) and environmental conditions (e.g., humidity and temperature). Further work needs to explore the environmental and health risks associated with the application of different disinfectants. Suggestions are to combine natural agents with antiviral and microbial properties such as plant extracts and nanoparticles (e.g., titanium dioxide or silver) which are known as antimicrobial agents with active ingredients used in the available disinfectants on the market. This highlights that we should be focusing our attention on investigating the efficacy of current disinfectants and developing new disinfectants for COVID-19.

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