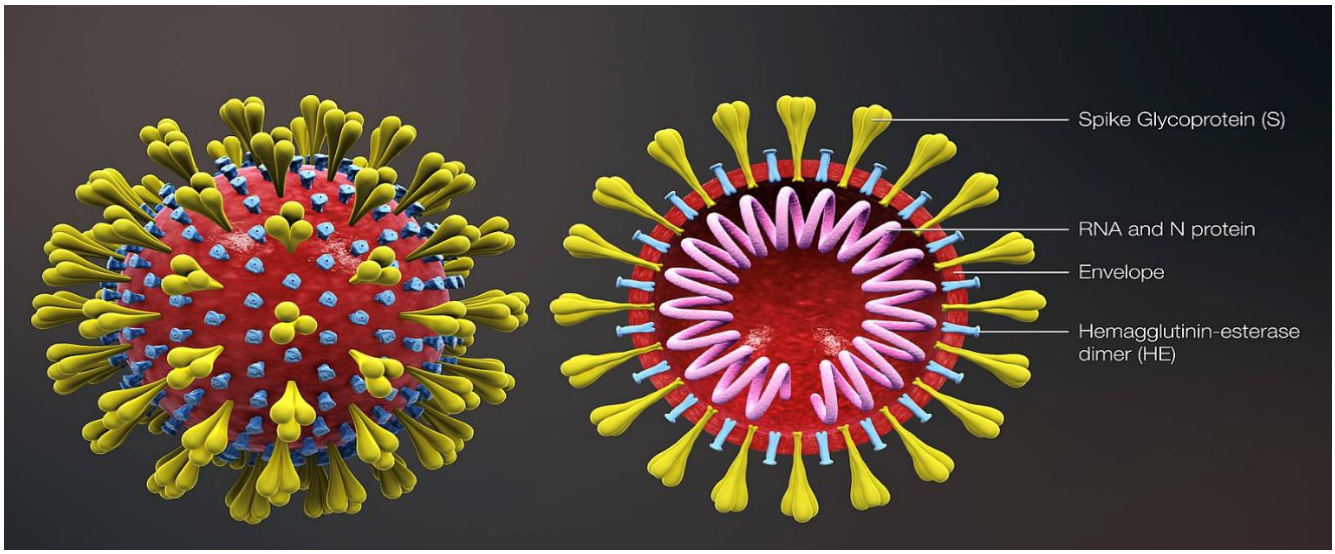
STRUCTURAL FEATURES OF CORONAVIRUS

The coronavirus has a spherical shape with a diameter of 120 nm on average. The virus envelope is a lipid bilayer which is varnished with glycoproteins (projecting outside as “spikes” and transmembrane proteins. These proteins enable the virus's attachment to the cell surface and its entry inside the infected cells. The lipid membrane engulfs the genetic RNA code of the virus which is then replicated inside the cell. The structural integrity of the virus's membrane, the defined topology and tertiary structure of membrane proteins, and the conserved structure and activity of the virion genome are all critical factors for the infectivity of the virus. Thus, any significant damage or disruption of these entities renders the virus inactive and prevents its infectivity.



Human coronaviruses can remain infectious on inanimate surfaces at room temperature for up to 9 days. At a temperature of 30°C or more the duration of persistence is shorter. Contamination of frequent touch surfaces in healthcare settings are therefore a potential source of viral transmission.

Disinfectants and antiseptics are used extensively to sterilize surfaces and spaces. An area or a device is considered sterilized when the disinfectant completely kills and removes microbial infecting agents. The ability of a disinfectant to deactivate a microbe depends on the mode of action of the chemical, the molecular structure of the pathogen's surface, and the intracellular vulnerability.

The WHO recommends “to ensure that environmental cleaning and disinfection procedures are followed consistently and correctly. Thoroughly cleaning environmental

surfaces with water and detergent and applying commonly used hospital-level disinfectants (such as sodium hypochlorite) are effective and sufficient procedures." The typical use of bleach is at a dilution of 1:100 of 5% sodium hypochlorite resulting in a final concentration of 0.05%. Our summarized data with coronaviruses suggest that a concentration of 0.1% is effective in 1 min. That is why it seems appropriate to recommend a dilution 1:50 of standard bleach in the coronavirus setting. For the disinfection of small surfaces ethanol (62–71%; carrier tests) revealed a similar efficacy against coronavirus. A concentration of 70% ethanol is also recommended by the WHO for disinfecting small surfaces.

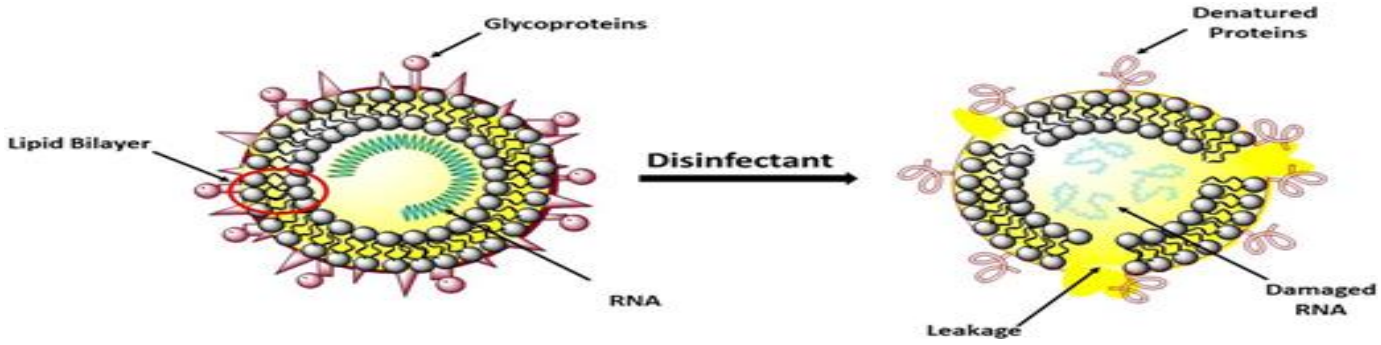
The WHO recommends to preferably apply alcohol-based hand rubs for the decontamination of hands, e.g. after removing gloves. Two WHO recommended formulations (based on 80% ethanol or 75% 2-propanol) have been evaluated in suspension tests against SARS-CoV and MERS-CoV, and both were described to be very effective. No in vitro data were found on the efficacy of hand washing against coronavirus contaminations on hands. In Taiwan, however, it was described that installing hand wash stations in the emergency department was the only infection control measure which was significantly associated with the protection from healthcare workers from acquiring the SARS-CoV, indicating that hand hygiene can have a protective effect. Compliance with hand hygiene can be significantly higher in an outbreak situation but is likely to remain an obstacle especially among physicians. Transmission in healthcare settings can be successfully prevented when appropriate measures are consistently performed.

CHEMICAL DISINFECTANTS AND ANTISEPTICS AND THEIR EFFECTS ON THE VIRUS

- Alcohols

The biocidal activity of alcohols is dependent on their concentration and hydroaffinity. The optimal concentration for antimicrobial activity is at 60–80% of alcohol where ethanol is superior to isopropanol against hydrophilic viruses, such as rotavirus, human immunodeficiency virus (HIV), and coronaviruses, while isopropanol is more active against lipophilic viruses, such poliovirus and hepatitis A virus (HAV). Ethanol and isopropanol are capable of destroying coronavirus at 70–90% concentrations within 30 s. It is believed that the alcohol causes membrane damage and denaturing of virus's proteins in addition to damaging the RNA. The strong ability of these alcohols to form hydrogen

bonding and their amphoteric nature allow them to disrupt the tertiary structure of proteins by disrupting the intramolecular hydrogen bonds within the structure.



- Oxidizing agents

Peroxide-based disinfectants, such as hydrogen peroxide and peroxyacetic acid, target the oxidation of thiol groups and disulfide bonds of proteins and denature them. Hydrogen peroxide is virucidal at 1–3% concentrations and it can deactivate SARS-CoV within a minute; it is even more potent in the gas phase. The peroxyacetic acid is more active than hydrogen peroxide against a broad spectrum of pathogens and at lower concentrations (~0.3%); thus, it is frequently used to disinfect medical devices. Both peroxy compounds produce hydroxyl radicals that attack different parts of the virus including lipid membrane, proteins, and nucleic acids.

- Chlorine-releasing agents

Household bleach is one of the most used domestic disinfectants due to its availability, low cost, low toxicity, and a wide range of biocidal activity.

The active chemical of bleach is sodium hypochlorite which is usually present at a concentration range of 3–6%. At low pH (4–7), the hypochlorite anion gets protonated and exists in equilibrium with hypochlorous acid, which will be the predominant species. It is believed that the acid is the active biocidal agent due to its permeability of membranes and strong oxidizing ability which damages the lipids of the membrane and the nucleic acids. As the pH of the solution increases, the hypochlorite ion becomes predominant and the biocidal activity decreases.

- Formaldehyde and glutaraldehyde

Both compounds are considering high-level disinfectants for medical devices and surgical equipment. The use of formaldehyde is limited, however, as compared to glutaraldehyde, due to its strong odor and fumes and because it is listed by OSHA as a possible carcinogen. These aldehydes disinfect bacteria and viruses by alkylating their proteins and nucleic acids and they are active against coronavirus at a concentration range 0.5–3% within 2 min of exposure.

- Iodine-releasing agents

Iodophores are iodine-releasing agents formed from a complex of iodine with a solubilizing agent in aqueous solutions since iodine alone is not stable in water. For example, povidone-iodine has been long used as an antiseptic on skin and tissues for a broad spectrum of bacteria. The released elemental iodine is able to penetrate the membrane and attack proteins at the sulfuryl and disulfide bonds in addition to damaging the nucleic acids. Studies have shown that povidone-iodine is able to deactivate SARS-CoV in suspension within seconds at a concentration of 1% or less.

- Quaternary ammonium compounds

Quaternary ammonium compounds (QACs) are effective disinfectants that are used widely, Generally, one of the substituents is a long alkyl chain, while the other three are smaller in size. Such a structure facilitates the formation of micelles which leads to their biocidal activity through the disintegration (lysing) of the pathogens' membranes and, hence, the loss of their structural integrity. One group of the QACs family that is widely used as a biocidal agent is the alkyldimethylbenzylammonium chloride where structural variations are associated with the length of the alkyl group. These are active against coronaviruses at less than 1% concentration and within an exposure time of a minute or less. Another group of these QACs, which gained attention as disinfectants, is the one where the N-atom has two alkyl substituents of the same structure. The popularity of these dialkyl quaternaries is due to their ability to retain biocidal activity in the presence of anionic residues and hard water.

References

Kannan, S., P. Shaik Syed Ali, A. Sheeza, and K. Hemalatha. "COVID-19 (Novel Coronavirus 2019)-recent trends." Eur. Rev. Med. Pharmacol. Sci 24, no. 4 (2020): 2006-2011.

https://www.journalofhospitalinfection.com/article/S0195-6701(20)30046-3/fulltext

https://www.ajicjournal.org/article/S0196-6553(09)00594-X/fulltext

https://iwaponline.com/jwh/article/18/5/843/75589/Chemical-disinfectants-of-COVID-19-an-overview

https://link.springer.com/article/10.1007/s40121-018-0200-7

https://cmr.asm.org/content/12/1/147