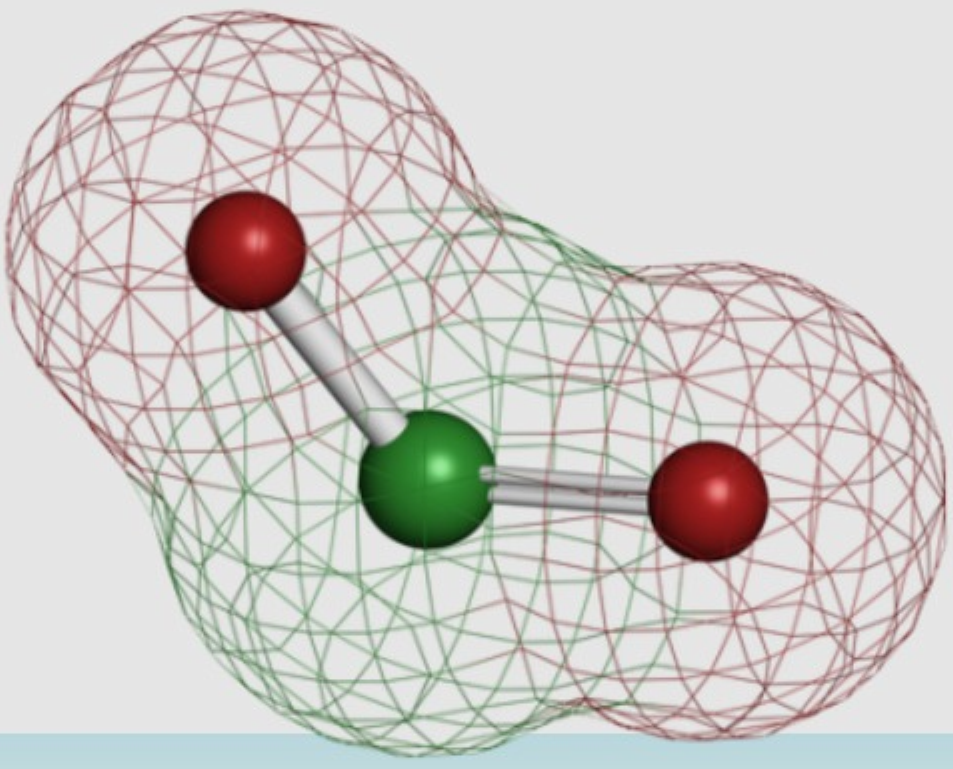
CHLORINE DIOXIDE

Learn About CD
- What is CD?
- What does it kill?
- Material Compatibility
- CD Process
- Biological Indicators

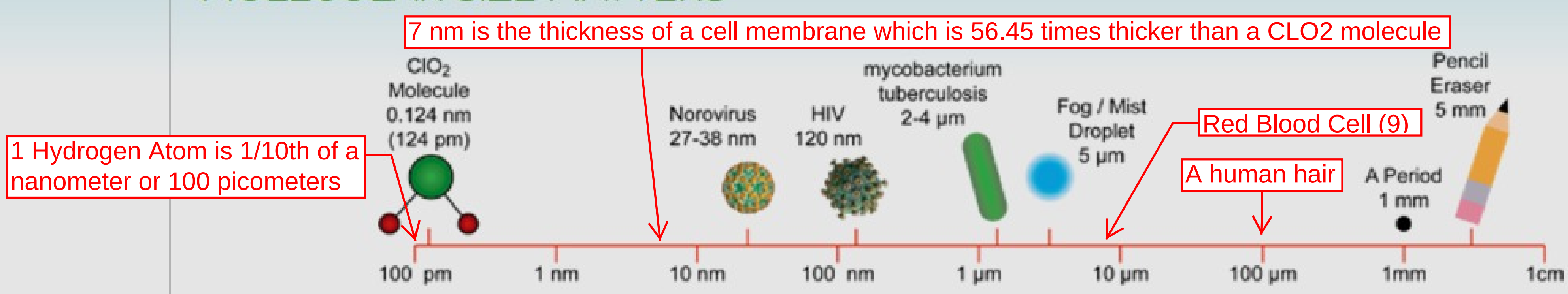
Where is it Used? How does it Work?

GENERAL

Chlorine dioxide (ClO_2) is a yellow-green gas with an odor similar to chlorine with excellent distribution, penetration and sterilization abilities due to its gaseous nature. Although chlorine dioxide has *chlorine* in its name, its properties are very different, much like carbon dioxide is different than elemental *carbon*. Chlorine dioxide has been recognized as a disinfectant since the early 1900s and has been approved by the US Environmental Protection Agency (EPA) and the US Food and Drug Administration (FDA) for many applications. It has been demonstrated effective as a broad spectrum, anti-inflammatory, bactericidal, fungicidal, and virucidal agent, as well as a deodorizer, and also able to inactivate beta-lactams and destroy both pinworms and their eggs.



MOLECULAR SIZE MATTERS



As can be seen in the chart above, the size of a chlorine dioxide gas molecule is 0.124 nm, much smaller than microorganisms and viruses, allowing the gas to easily penetrate into any areas where these microorganisms might be concealed.

CHEMICAL PROPERTIES

Although chlorine dioxide has "chlorine" in its name, its chemistry is radically different from that of chlorine. When reacting with other substances, it is weaker and more selective, allowing it to be a more efficient and effective sterilizer. For example, it does not react with ammonia or most organic compounds. Chlorine dioxide oxidizes products rather than chlorinating them, so unlike chlorine, chlorine dioxide will not produce environmentally undesirable organic compounds containing chlorine. Chlorine dioxide is also a visible yellow-green gas allowing it to be measured in real-time with photometric devices.

ANTIMICROBIAL PROPERTIES / MODE OF ACTION

Chlorine dioxide (ClO_2) acts as an oxidizing agent and reacts with several cellular constituents, including the cell membrane of microbes. By "stealing" electrons from them (oxidation), it breaks their molecular bonds, resulting in the death of the organism by the breakup of the cell. By altering the proteins involved in the structure of microorganisms, their enzymatic function is broken and causes very rapid bacterial kills. This oxidative attack on many proteins simultaneously is behind the potency of chlorine dioxide and also prevents microorganisms from mutating to a resistant form. Because of the selective reactivity of chlorine dioxide, its antimicrobial action is retained longer in the presence of organic matter than most other decontaminating agents.

INACTIVATION OF SPORES VS. BACTERIA

The difference between spore and bacterial inactivation is the same as the difference between sterilization and disinfection. For a chemical agent to be classified as a sterilant, it must be demonstrated to be effective at inactivating spores. Spores are among the hardest organisms to kill and for this reason *sterilizing* agents are considered the most rigorous decontaminating agents and offer complete kill of all antimicrobial life. Disinfection, on the other hand, does not require the complete inactivation of spores or all microbial life and is normally validated against a few vegetative bacteria species. For this reason, *disinfecting* agents are less rigorous decontaminating agents and are not as effective as sterilizing agents.

"Bacterial endospores are one of the most persistent forms of microbial life and typically require aggressive inactivation procedures. Vegetative bacteria are generally much more easily inactivated than are bacterial endospores. This is primarily because the sensitive areas of bacteria are easily contacted by chemosterilizing agents. The spore, however, has a more complex structure than the vegetative bacterial cell. Its sensitive material is contained within a core and that core is surrounded by a cortex and spore coats. These coats tend to act as a permeability barrier to the entry of chlorine dioxide and other compounds" (Knapp, 2000).

ENVIRONMENTAL IMPACT

Chlorine dioxide's special properties make it an ideal choice to meet the challenges of today's environmentally concerned world and is an environmentally preferred alternative to elemental chlorine. When chlorine reacts with organic matter, undesirable pollutants such as dioxins and bio-accumulative toxic substances are produced. Thus, the EPA supports the replacement of chlorine with chlorine dioxide because it eliminates the production of these pollutants. It is a perfect replacement for chlorine, providing all of chlorine's benefits without any of its weaknesses and detriments. Most importantly, chlorine dioxide does not chlorinate organic material, eliminating the formation of trihalomethanes (THMs), haloacetic acids (HAAs) and other chlorinated organic compounds. This is particularly important in the primary use for chlorine dioxide, which is water disinfection. Other properties of chlorine dioxide make it more effective than chlorine, requiring a lower dose and resulting in a lower environmental impact.

USES

Chlorine dioxide is widely used as an antimicrobial and as an oxidizing agent in drinking water, poultry process water, swimming pools, and mouthwash preparations. It is used to sanitize fruit and vegetables and also equipment for food and beverage processing and widely used in life science research laboratories. It is also employed in the health care industry to decontaminate rooms, passthroughs, isolators and also as a sterilant for product and component sterilization. It is also extensively used to bleach, deodorize, and detoxify a wide variety of materials, including cellulose, paper-pulp, flour, leather, fats and oils, and textiles. Approximately 4 to 5 million pounds are used daily.

WATER SOLUBILITY

Unlike many decontaminating agents, chlorine dioxide has the unique ability to retain its sterilization capacity in water. In order to maximize process reproducibility and minimize materials effects when using the chlorine dioxide gas it is best to avoid pools or puddles of water. However, if small amounts of water are present the efficacy of chlorine dioxide is not affected. The reason that small amounts of water will not impact sterilization efficacy is that chlorine dioxide is readily soluble in water. The partition coefficient ($CClO_2(H_2O)/CClO_2(air)$) of chlorine dioxide at 22°C and 101 kPa is about 38 (Masschelein). And provided that the quantity of water is small the gas concentration in the water reaches equilibrium quickly.

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Cell Biology/Introduction/Cell size

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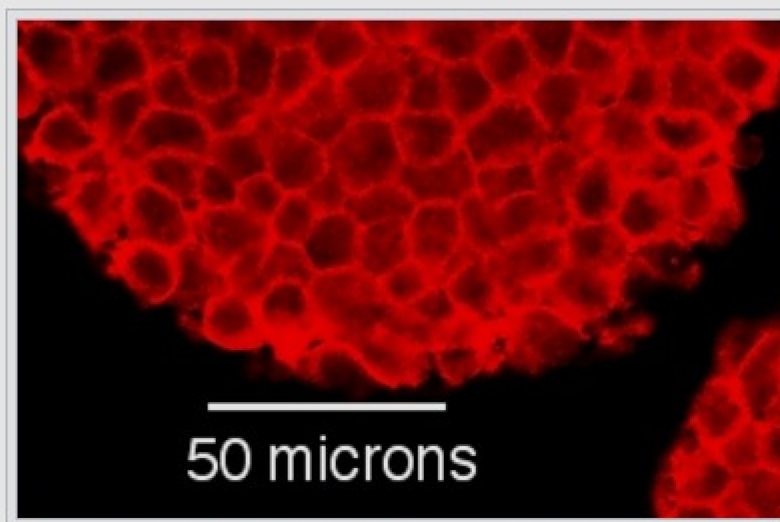
Size of Cells [edit]

Although it is generally the case that biological cells are too small to be seen at all without a microscope, there are exceptions as well as considerable range in the sizes of various cell types. Eukaryotic cells are typically 10 times the size of prokaryotic cells (these cell types are discussed in the next Chapter). Plant cells are on average some of the largest cells, probably because in many plant cells the inside is mostly a water filled vacuole.



Cells are so small that even a cluster of these cells from a mouse only measures 50 microns

So, you ask, what are the relative sizes of biological molecules and cells? The following are all approximations:

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0.1 nm (nanometer) diameter of a hydrogen atom
0.8 nm Amino Acid    0.124 nm is the  diameter of a Chlorine Dioxide (CLO2) molecule, about 25% larger than a Hydrogen Atom.
  2 nm Diameter of a DNA Alpha helix
  4 nm Globular Protein
  6 nm microfilaments
 7 nm thickness cell membranes
 20 nm Ribosome
 25 nm Microtubule
 30 nm Small virus (Picornaviruses)    242 times larger than a Chlorine Dioxide (CLO2) molecule
                                       and 300 times smaller than a Red Blood Cell
 30 nm Rhinoviruses
 50 nm Nuclear pore
100 nm HIV
120 nm Large virus (Orthomyxoviruses, includes influenza virus)
150-250 nm Very large virus (Rhabdoviruses, Paramyxoviruses)
150-250 nm small bacteria such as Mycoplasma
200 nm Centriole
200 nm (200 to 500 nm) Lysosomes
200 nm (200 to 500 nm) Peroxisomes
800 nm giant virus Mimivirus
  1 µm (micrometer)
(1 - 10 µm) the general sizes for Prokaryotes
  1 µm Diameter of human nerve cell process
  2 µm E.coli - a bacterium    About 16,129 times larger than a CLO2 molecule
  3 µm Mitochondrion
  5 µm length of chloroplast
  6 µm (3 - 10 micrometers) the Nucleus
  9 µm Human red blood cell    About 72,500 times larger than a CLO2 molecule
 10 µm
       (10 - 30 µm) Most Eukaryotic animal cells
       (10 - 100 µm) Most Eukaryotic plant cells
 90 µm small Amoeba    100 micro meters is the  diameter of a human hair (1/10th of a millimeter)
120 µm Human Egg
up to 160 µm Megakaryocyte
up to 500 µm  giant bacterium Thiomargarita
up to 800 µm  large Amoeba
  1 mm (1 millimeter, 1/10th cm)
  1 mm Diameter of the squid giant nerve cell
up to 40mm Diameter of giant amoeba Gromia Sphaerica
  120 mm Diameter of an ostrich egg (a dinosaur egg was much larger)
  3 meters Length of a nerve cell of giraffe's neck
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What limits cell sizes?

- Prokaryotes — Limited by efficient metabolism
- Animal cells (eukaryotic) — Limited by surface area to volume ratio
- Plant cells (eukaryotic) — Have large sizes due to large central vacuole, which is responsible for their growth

Related reading [edit]

- Some early history related to the development of an understanding of the existence and importance of cells. The importance of microscopy.

Category: Cell Biology

1 micrometer (µm) = thousandth part of millimeter

= 10^{-3} mm

= 10^{-6} m

1 nanometer (nm) = thousandth part of micrometer

= 10^{-3} µm

= 10^{-6} mm

= 10^{-9} m

The smallest virus is 18 nm
or 180 Angstroms

1 Angstrom unit (A°)= tenth part of nanometer

= 10^{-10} m

The size of a hydrogen atom

100 picometers is equal to 1 Angstrom and 1 Chlorine Dioxide molecule is 124 picometers or 1.24 Angstroms and so just about 25% bigger than a Hydrogen Atom.