

Biological Efficacy of Chlorine Dioxide

Clordisys' Chlorine Dioxide Gas is registered with the United States Environmental Protection Agency as a sterilizer. The U.S. EPA defines a sterilizer as able "to destroy or eliminate all forms of microbial life including fungi, viruses, and all forms of bacteria and their spores. With this classification from the EPA, it can be thought that Chlorine Dioxide Gas will eliminate all viruses, bacteria, fungi, and their spores. Testing has been done using Chlorine Dioxide on a multitude of specific organisms, and that information is found below. It is not a complete list of organisms in which Chlorine Dioxide Gas is effective against, only a sample of organisms in which Chlorine Dioxide has been successfully tested against. To date, no organism tested against Chlorine Dioxide Gas has proved resistant.

Again CSI's gaseous chlorine dioxide is registered with the EPA as a sterilant.

Product: CSI CD CARTRIDGE
EPA Reg#: 80802-1
Registrant: CLORDISYS SOLUTIONS, INC
Approval Date: 02/25//2005
Active Ingredients: Sodium chlorite 72.8%

With the US-EPA there are various levels of kill and registration. For example List G is the norovirus (Norwalk like Virus). CSI's system is registered under List A (Sterilizers). Since chlorine dioxide is demonstrated effective as a sterilant and our product is registered as a higher level of kill, Sterilizers/Sporicides it is then established that we are effective against viruses. Simply stated registration as a sterilant means we kill everything, bacteria, fungi, spores and viruses. In addition by list G it can be seen that chlorine dioxide is specifically effective against noroviruses.

EPA registered products effective against Methicillin Resistant *Staphylococcus aureus* (MRSA), Vancomycin Resistant *Enterococcus faecalis* or *faecium* (VRE), human *Norovirus* (Norwalk like Virus), as well as products used for medical waste treatments in healthcare/medical facilities are also included. The lists are organized alphabetically by product names and by numerical order of their EPA Registration numbers (EPA Reg#).

Only primary product names from the primary registrants are included in the lists. All EPA's registered pesticides must have an EPA registration number (EPA Reg#). Alternative brand names have the same EPA Reg# as the primary product name. The EPA Reg# of a product for primary registrants consists of two set of numbers separated by a hyphen (-). (for example EPA Reg#12345-12.) The first set of numbers refers to the registrant's identification number and the second set of numbers represents the product number. A distributor's product is the same as the primary product, and may use a different name, but must have the first two sets of EPA Reg# of the primary registrant, plus a third set of numbers that represents the Distributor/Relabeler ID number. (for example EPA Reg#12345-12-2567.)

An EPA Establishment number (EPA Est#) is the place where the pesticide, formulation or a device is produced and it is indicated by a set of codes which consist of the registrant's ID number followed by the State where the product is made and facility number (for example EPA Est.#12345-CA-2).

The above lists are updated periodically to reflect label changes, cancellations, and transfers of product registrations. Information on the above list does not constitute a label replacement. Inclusion of products in these lists does not

Below is from the EPA-registered Disinfectants website

- [List A: EPA's Registered Antimicrobial Products as Sterilizers \(PDF\)](#) (11 pp, 46k)
- [List B: EPA Registered Tuberculocide Products Effective Against *Mycobacterium tuberculosis* \(PDF\)](#) (33 pp, 162k)
- [List C: EPA's Registered Antimicrobial Products Effective Against Human HIV-1 Virus \(PDF\)](#) (89 pp, 417)
- [List D: EPA's Registered Antimicrobial Products Effective Against Human HIV-1 and Hepatitis B Virus \(PDF\)](#) (30 pp, 128k)
- [List E: EPA's Registered Antimicrobial Products Effective Against *Mycobacterium tuberculosis* Human HIV-1 and Hepatitis B Virus \(PDF\)](#) (8 pp, 53k)
- [List F: EPA's Registered Antimicrobial Products Effective Against Hepatitis C Virus \(PDF\)](#) (22 pp, 94k)
- [List G: EPA's Registered Antimicrobial Products Effective Against *Norovirus* \(PDF\)](#) (7 pp, 51k)
- [List H: EPA's Registered Antimicrobial Products Effective Against Methicillin Resistant *Staphylococcus aureus* \(MRSA\) and Vancomycin Resistant *Enterococcus faecalis* or *faecium* \(VRE\) \(PDF\)](#) (40 pp, 566k)
- [List J: EPA's Registered Antimicrobial Products for Medical Waste Treatment \(PDF\)](#) (4 pp, 36k)

Take from website:

<http://www.epa.gov/oppad001/chemreindex.htm>

constitute an endorsement of one product over another. Before applying any antimicrobial product, users must determine if the product is approved for the intended use site/pest. Check the container/package label to determine if the intended use site/pest is written on the label. Always read the product label of an EPA-registered product label thoroughly before use. It is a violation of Federal Law to use an EPA registered product in a manner inconsistent with its label and labeling.

The approved label of a product can be found in the [Pesticide Product Label System \(PPLS\) database](#). To obtain a product label, search the PPLS database by providing the EPA Reg# of the primary product (registrant's identification number and its product number). Refer to the [PPLS Web page](#) for additional information about the Pesticide Product Label System (PPLS) database and the TIF software program for viewing the label images.

For information about a disinfectant product, search for the product in the [California Department of Pesticide Regulation \(CDPR\)](#) database or subscribe to the [National Pesticide Information Resource Service \(NPIRS\)](#)

More information about product name search, active chemical ingredient search, Registrant/Company search and Pesticide Product Label Search is available from the [Pesticide Product Information Service \(PPIS\)](#)

Definitions of an antimicrobial product as well as the different types (categories) of antimicrobial products as used by EPA under Federal Insecticide Fungicide and Rodenticide Act (FIFRA), rules and regulation can be found on the [What are Antimicrobial Pesticides?](#)

Below is from the [What are Antimicrobial Pesticides? Web page:](#) http://www.epa.gov/oppad001/ad_info.htm

What Are Antimicrobial Pesticides?

Antimicrobial pesticides are substances or mixtures of substances used to destroy or suppress the growth of harmful microorganisms whether bacteria, viruses, or fungi on inanimate objects and surfaces. Antimicrobial products contain about 275 different active ingredients and are marketed in several formulations: sprays, liquids, concentrated powders, and gases. Today, approximately one billion dollars each year are spent on a variety of different types of antimicrobial products. More than 5000 antimicrobial products are currently registered with the U.S. Environmental Protection Agency (EPA) and sold in the marketplace. Nearly 60% of antimicrobial products are registered to control infectious microorganisms in hospitals and other health care environments.

Antimicrobial pesticides have two major uses:

- 1.) disinfect, sanitize, reduce, or mitigate growth or development of microbiological organisms
- 2.) protect inanimate objects (for example floors and walls), industrial processes or systems, surfaces, water, or other chemical substances from contamination, fouling, or deterioration caused by bacteria, viruses, fungi, protozoa, algae, or slime.

This category does not include certain pesticides intended for food use; but does encompass pesticides with a wide array of other uses. For example, antimicrobial pesticides act as preserving agents in paints, metalworking fluids, wood supports, and many other products to prevent their deterioration. Some examples of antimicrobial pesticide chemicals can be found in the [Antimicrobial Chemical Indexes](#).

Types of Antimicrobial Products

Antimicrobial products are divided into two categories based on the type of microbial pest against which the product works. Non-public health products are used to control growth of algae, odor-causing bacteria, bacteria which cause spoilage, deterioration or fouling of materials and microorganisms infectious only to animals. This general category includes products used in cooling towers, jet fuel, paints, and treatments for textile and paper products. Public health products are intended to control microorganisms infectious to humans in any inanimate environment. The more commonly used public health antimicrobial products include the following:

Sterilizers (Sporicides): Used to **destroy or eliminate all forms of microbial life including fungi, viruses, and all forms of bacteria and their spores**. Spores are considered to be the most difficult form of microorganism to destroy. Therefore, EPA considers the term Sporicide to be synonymous with "Sterilizer." Sterilization is critical to infection control and is widely used in hospitals on medical and surgical, instruments and equipment. Types of sterilizers include steam under pressure (autoclaving), dry heat ovens, low temperature gas (ethylene oxide), and liquid chemical sterilants. Gaseous

and dry heat sterilizers are used primarily for sterilization of medical instruments. Liquid sterilants are primarily used for delicate instruments which cannot withstand high temperature and gases.

Disinfectants: Used on hard inanimate surfaces and objects to destroy or irreversibly inactivate infectious fungi and bacteria but not necessarily their spores. Disinfectant products are divided into two major types: hospital and general use. Hospital type disinfectants are the most critical to infection control and are used on medical and dental instruments, floors, walls, bed linens, toilet seats, and other surfaces. General disinfectants are the major source of products used in households, swimming pools, and water purifiers.

Sanitizers: Used to reduce, but not necessarily eliminate, microorganisms from the inanimate environment to levels considered safe as determined by public health codes or regulations. Sanitizers include food contact and non-food contact products. Sanitizing rinses for surfaces such as dishes and cooking utensils, as well as equipment and utensils found in dairies, food-processing plants, and eating and drinking establishments comprise the food contact Sanitizers. These products are important because they are used on sites where consumable food products are placed and stored. Non-food contact surface sanitizers include carpet sanitizers, air sanitizers, laundry additives, and in-tank toilet bowl sanitizers.

Antiseptics and Germicides: Used to prevent infection and decay by inhibiting the growth of microorganisms. Because these products are used in or on living humans or animals, they are considered drugs and are thus approved and regulated by the Food and Drug Administration (FDA).

Below is a table of some of the organisms that chlorine dioxide has been tested with.

<u>Bacteria:</u>	Ref.
<i>Blakeslea trispora</i>	28
<i>Bordetella bronchiseptica</i>	8
<i>Brucella suis</i>	30
<i>Burkholderia mallei</i>	36
<i>Burkholderia pseudomallei</i>	36
<i>Campylobacter jejuni</i>	39
<i>Clostridium botulinum</i>	32
<i>Corynebacterium bovis</i>	8
<i>Coxiella burneti (Q-fever)</i>	35
<i>E. coli ATCC 11229</i>	3
<i>E. coli ATCC 51739</i>	1
<i>E. coli K12</i>	1
<i>E. coli O157:H7 13B88</i>	1
<i>E. coli O157:H7 204P</i>	1
<i>E. coli O157:H7 ATCC 43895</i>	1
<i>E. coli O157:H7 EDL933</i>	13
<i>E. coli O157:H7 G5303</i>	1
<i>E. coli O157:H7 C7927</i>	1
<i>Erwinia carotovora (soft rot)</i>	21
<i>Franscicella tularensis</i>	30
<i>Fusarium sambucinum (dry rot)</i>	21
<i>Fusarium solani var. coeruleum (dry rot)</i>	21
<i>Helicobacter pylori</i>	8

<u>Bacteria:</u>	Ref.
<i>Helminthosporium solani (silver scurf)</i>	21
<i>Klebsiella pneumonia</i>	3
<i>Lactobacillus acidophilus NRRL B1910</i>	1
<i>Lactobacillus brevis</i>	1
<i>Lactobacillus buchneri</i>	1
<i>Lactobacillus plantarum</i>	5
<i>Legionella</i>	38
<i>Legionella pneumophila</i>	42
<i>Leuconostoc citreum TPB85</i>	1
<i>Leuconostoc mesenteroides</i>	5
<i>Listeria innocua ATCC 33090</i>	1
<i>Listeria monocytogenes F4248</i>	1
<i>Listeria monocytogenes F5069</i>	19
<i>Listeria monocytogenes LCDC-81-861</i>	1
<i>Listeria monocytogenes LCDC-81-886</i>	19
<i>Listeria monocytogenes Scott A</i>	1
<i>Methicillin-resistant Staphylococcus aureus (MRSA)</i>	3
<i>Multiple Drug Resistant Salmonella typhimurium (MDRS)</i>	3
<i>Mycobacterium bovis</i>	8
<i>Mycobacterium fortuitum</i>	42
<i>Pediococcus acidilactici PH3</i>	1
<i>Pseudomonas aeruginosa</i>	3

Bacteria:	Ref.
<i>Pseudomonas aeruginosa</i>	8
<i>Salmonella</i>	1
<i>Salmonella spp.</i>	2
<i>Salmonella Agona</i>	1
<i>Salmonella Anatum Group E</i>	1
<i>Salmonella Choleraesins ATCC 13076</i>	1
<i>Salmonella choleraesuis</i>	8
<i>Salmonella Enterica (PT30) BAA-1045</i>	1
<i>Salmonella Enterica S. Enteritidis</i>	13
<i>Salmonella Enterica S. Javiana</i>	13
<i>Salmonella Enterica S. Montevideo</i>	13
<i>Salmonella Enteritidis E190-88</i>	1
<i>Salmonella Javiana</i>	1
<i>Salmonella newport</i>	4
<i>Salmonella Typhimurium C133117</i>	1
<i>Salmonella Anatum Group E</i>	1
Shigella	38
<i>Staphylococcus aureus</i>	23
<i>Staphylococcus aureus ATCC 25923</i>	1
<i>Staphylococcus faecalis ATCC 344</i>	1
Tuberculosis	3
<i>Vancomycin-resistant Enterococcus faecalis (VRE)</i>	3
<i>Vibrio strain Da-2</i>	37
<i>Vibrio strain Sr-3</i>	37
<i>Yersinia enterocolitica</i>	40
<i>Yersinia pestis</i>	30
<i>Yersinia ruckerii ATCC 29473</i>	31

Viruses:	Ref
Adenovirus Type 40	6
Canine Parvovirus	8
Coronavirus	3
Feline Calici Virus	3
Foot and Mouth disease	8
Hantavirus	8
Hepatitis A Virus	3
Hepatitis B Virus	8
Hepatitis C Virus	8

Viruses:	Ref
Human coronavirus	8
Human Immunodeficiency Virus	3
Human Rotavirus type 2 (HRV)	15
Influenza A	22
Minute Virus of Mouse (Parovirus)(MVM-i)	8
Minute Virus of Mouse (Parovirus)(MVM-p)	8
Mouse Hepatitis Virus (MHV-A59)	8
Mouse Hepatitis Virus (MHV-JHM)	8
Mouse Parvovirus type 1 (MPV-1)	8
Murine Parainfluenza Virus Type 1 (Sendai)	8
Newcastle Disease Virus	8
Norwalk Virus	8
Poliovirus	20
Rotavirus	3
Sialodscryoadenitis Virus (Coronavirus)(SDAV)	8
Simian rotavirus SA-11	15
Theiler's Mouse Encephalomyelitis Virus (TMEV)	8
Vaccinia Virus	10

Algae/Fungi/Mold/Yeast:	Ref.
<i>Alternaria alternata</i>	26
<i>Aspergillus aeneus</i>	28
<i>Aspergillus aurolatus</i>	28
<i>Aspergillus brunneo-uniseriatus</i>	28
<i>Aspergillus caespitosus</i>	28
<i>Aspergillus cervinus</i>	28
<i>Aspergillus clavatonanicus</i>	28
<i>Aspergillus clavatus</i>	28
<i>Aspergillus egyptiacus</i>	28
<i>Aspergillus elongatus</i>	28
<i>Aspergillus fischeri</i>	28
<i>Aspergillus fumigatus</i>	28
<i>Aspergillus giganteus</i>	28
<i>Aspergillus longivesica</i>	28
<i>Aspergillus niger</i>	12
<i>Aspergillus ochraceus</i>	28
<i>Aspergillus parvathecius</i>	28
<i>Aspergillus sydowii</i>	28

Algae/Funghi/Mold/Yeast:	Ref.
Aspergillus unguis	28
Aspergillus ustus	28
Aspergillus versicolor	28
Botrytis species	3
Candida spp.	5
Candida albicans	28
Candida dubliniensis	28
Candida maltosa	28
Candida parapsilosis	28
Candida sake	28
Candida sojae	28
Candida spp.	5
Candida tropicalis	28
Candida viswanathil	28
Chaetomium globosum	7
Cladosporium cladosporioides	7
Debaryomyces etchellsii	28
Eurotium spp.	5
Fusarium solani	3
Lodderomyces elongisporus	28
Mucor circinelloides	28
Mucor flavus	28
Mucor indicus	28
Mucor mucedo	28
Mucor rademosus	28
Mucor ramosissimus	28
Mucor saturnus	28
Penicillium chrysogenum	7
Penicillium digitatum	3
Penicillium herquei	28
Penicillium spp.	5
Phormidium boneri	3
Pichia pastoris	3
Poitrasia circinans	28
Rhizopus oryzae	28
Saccharomyces cerevisiae	3
Stachybotrys chartarum	7
T-mentag (athlete's foot fungus)	3

Bacterial Spores:	Ref.
<i>Alicyclobacillus acidoterrestris</i>	17
<i>Bacillus coagulans</i>	12
<i>Bacillus anthracis</i>	10
<i>Bacillus anthracis Ames</i>	30
<i>Bacillus atrophaeus</i>	14
<i>Bacillus atrophaeus ATCC 49337</i>	31
<i>Bacillus megaterium</i>	12
<i>Bacillus polymyxa</i>	12
<i>Bacillus pumilus ATCC 27142</i>	12
<i>Bacillus pumilus ATCC 27147</i>	11
<i>Bacillus subtilis (globigii) ATCC 9372</i>	11
<i>Bacillus subtilis ATCC 19659</i>	31
<i>Bacillus subtilis 5230</i>	12
<i>Clostridium. sporogenes ATCC 19404</i>	12
<i>Geobacillus stearothermophilus ATCC 12980</i>	11
<i>Geobacillus stearothermophilus ATCC 7953</i>	31
<i>Geobacillus stearothermophilus VHP</i>	11
<i>Bacillus thuringiensis</i>	18

Chemical Decontamination:	Ref.
Mustard Gas	
Ricin Toxin	10
dihydronicotinamide adenine dinucleotide	24
microcystin-LR (MC-LR)	25
cylindrospermopsin (CYN)	25

Beta Lactams:	Ref.
Amoxicillin	29
Ampicillin	29
Cefadroxil	29
Cefazolin	29
Cephalexin	29
Imipenem	29
Penicillin G	29
Penicillin V	29

Protozoa:	Ref.
<i>Cryptosporidium parvum</i> Oocysts	9
<i>Chironomid larvae</i>	27

Microsporidia:	Ref.
<i>Encephalitozoon intestinalis</i>	41

As shown above Chlorine Dioxide Gas has proven effective at eliminating a wide range of organisms. Testing is still being performed on other organisms, and will be added to this list as results come in. If an organism is not listed here, it does not mean that Chlorine Dioxide Gas is ineffective against it. Please contact us to see if there is any data or information regarding your specific organism, or to arrange for testing to be done.

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