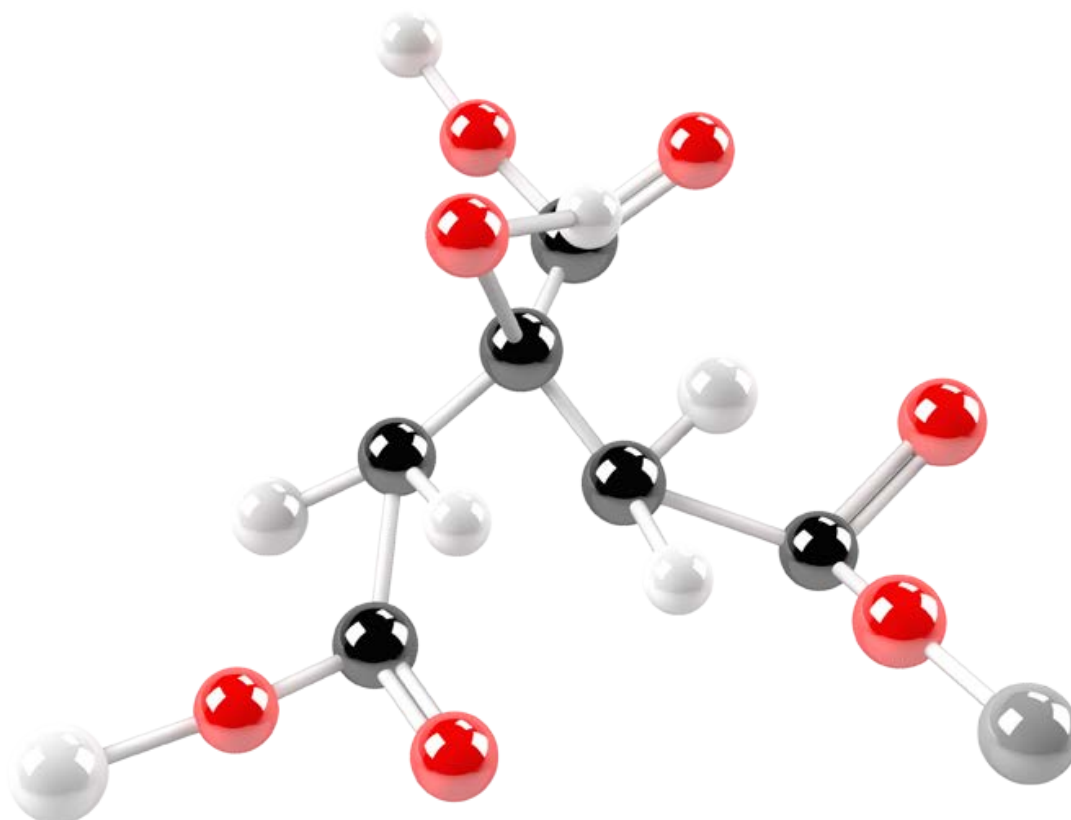


Silver Dihydrogen Citrate

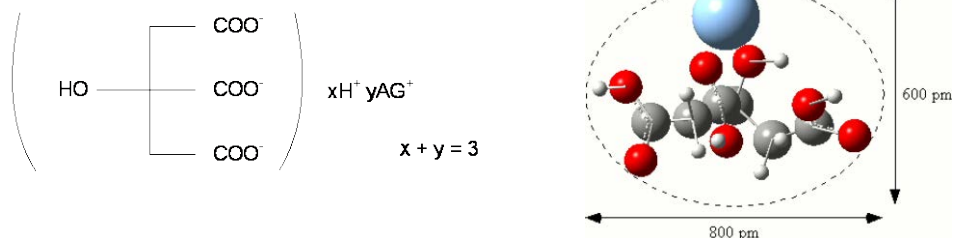
Technical Data Sheet



Characterization SILVER DIHYDROGEN CITRATE (SDC) is a patented antimicrobial based on stabilized silver ion complex produced by a unique electrochemical process with silver and citric acid.

Chemical nature Water soluble silver salt of citric acid.

Structure



Product form Colorless, low viscous liquid

Shelf Life greater than 5 years

Features/benefits SDC provides a broad spectrum antimicrobial activity and is effective against unwanted bacteria, fungi and viruses including pathogenic microorganisms. Its fast killing activity makes SDC an effective antimicrobial for many applications.

Applications Antimicrobial active in commercial and residential disinfection/sanitization products; Deodorant active for Personal Care products; Antimicrobial active/preservative for Personal Care products; Pharmaceutical; Agriculture; Industrial; Biofilm control; Food processing

Due to different national regulations for antimicrobials, biocides and preservatives, the local registration status has to be considered.

Mechanism of Action Silver has been used for centuries for its antimicrobial properties. In order for silver to be effective in killing microorganisms, it must be in an ionic form. SDC is a complex of one silver ion weakly bound to one citrate ion having the molecular complex $\text{AgC}_6\text{H}_7\text{O}_7$. SDC provides a stabilized form of silver ion in an organic acid (citric acid). The bioavailability of the ions allows for SDC to be rapidly effective against a broad spectrum of bacteria, viruses and fungi.

The bacterial outer membrane is called the cell wall. Bacterial cell walls are made of peptidoglycans which provide protection and rigidity to the organism. The exact membrane constitution depends on the type of bacteria. SDC utilizes a multiple prong attack against microorganisms. SDC targets an organism's cell wall (cell membrane). Silver ions are highly attracted to sulfur-containing thiol groups found in metabolic and structural proteins bound to the membrane surface. SDC targets these critical proteins and destroys their structure. This disruption of the organisms' membrane function and integrity lyses the membrane and the organism dies.

In addition to supporting the silver ion, citrate plays a key part in the effectiveness of SDC. Bacteria are actually attracted to SDC because they recognize citric acid as a food source. This "Trojan Horse" attack allows SDC to easily enter the microorganism through membrane transport proteins. Once inside the organism, SDC binds to DNA and intracellular proteins causing irreversible damage to the DNA and protein structure. Metabolic and reproductive functions halt, and the organism dies.

Viruses are much smaller than bacterial and fungal cells and do not have metabolic activity. Viruses present fewer targets sites on which a biocide can act. Silver targets the viral envelope

or capsid and the viral nucleic acid. Silver not only destroys the viral envelope or capsid, preventing the virus from attaching to a host cell, it also destroys the infectious component of the virus, the nucleic acid.

Efficacy

A 1:80 dilution (30 ppm ionic silver) demonstrates the following efficacy:

Effective in 30 seconds against:

Pseudomonas aeruginosa ATCC 15422; *Salmonella choleraesuis* ATCC 10708 ; HIV type1, Strain HTLV-IIIB; Influenza A (H1N1); Swine Influenza A (H1N1); Human Corona virus (SARS Surrogate), Rotavirus, Respiratory syncytial virus (RSV); Adenovirus Type 2; Influenza A ATCC VR-544, Hong Kong Strain; Avian Influenza A

Effective in 1 minute against:

Herpes simplex type I ATCC VR-733, Strain F(1); Murine Norovirus (MNV-1); Rhinovirus R37 ATCC VR-1147, Strain 151-1; Poliovirus type 2 ATCC VR-1002, Strain Lansing; Feline Calicivirus (Norwalk); Hepatitis B virus; Hepatitis C virus

Effective in 2 minutes against:

Staphylococcus aureus ATCC 6538; *E. coli* 0157 ATCC 43888; *Enterococcus faecium* (VRE)ATCC 700221; *Staphylococcus aureus* (MRSA) ATCC 700698; CA-MRSA, PVL-MRSA, *Campylobacter jejuni*, *Aceintobacter baumannii*; *Listeria monocytogenes* ATCC 19111; Carbapenem resistant *E. coli*; Carbapenem resistant *Klebsiella pneumonia*; Carbapenem resistant *Klebsiella pneumonia* NDM-1+

Effective in 5 minutes against:

Trichophyton mentagrophytes ATCC 9533

**Broad Spectrum Efficacy
Minimum Inhibitory
Concentration (MIC) of
SDC**

Microorganism	MIC of SDC (%)
Micrococcus luteus ATCC 10240	0.08
Escherichia coli ATCC 10536	0.08
Corynebacterium xerosis ATCC 373	0.12
Corynebacterium minutissimum ATCC 23348	0.12
Staphylococcus aureus ATCC 6538	0.16
Bacillus subtilis ATCC 6633	0.16
Enterobacter gergoviae ATCC 33028	0.16
Klebsiella pneumonia ATCC 4352	0.16
Proteus mirabilis ATCC 14153	0.16
Pseudomonas aeruginosa ATCC 15442	0.16
Pseudomonas fluorescens ATCC 17826	0.16
Propionibacterium acnes ATCC 6919	0.25
Candida albicans ATCC 10231	0.12
Malassezia furfur DSM 6171	0.25
Aspergillus niger ATCC 16404	0.50
Trichophyton mentagrophytes ATCC 9533	0.50

**Broad Spectrum Efficacy
Minimum Bactericidal
Concentration (MBC) of
SDC**

Microorganism	MBC of SDC (%)
Staphylococcus aureus ATCC 6538	0.31
Escherichia coli ATCC 10536	0.16
Pseudomonas aeruginosa ATCC 15442	0.08
Klebsiella pneumonia ATCC 4352	0.16
Corynebacterium minutissimum ATCC 23348	0.16
Candida albicans ATCC 10231	>1.25
Aspergillus niger ATCC 16404	>2.5
Trichophyton mentagrophytes ATCC 9533	0.08
Epidermohpyton floccosum DSM 10709	0.63

Residual Activity

Residual Microbicidal effect	Possesses a significant residual effect
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Safety Data

Acute mammalian toxicity package	<ul style="list-style-type: none"> • Acute oral: > 5000 mg/kg ; • Acute dermal toxicity > 5000 mg/kg ; • Primary eye irritation: Minimal effects clearing in less than 24 hours ; • Skin irritation: Mild or slight irritation (no irritation or slight erythema)
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Physical Properties

CAUTION: Concentrate will stain surfaces if contacted.	
Liquid/solid/gas	Liquid, water based
Foaming/non-foaming	Yes,(when formulated with SLS)
Odor	Odorless
Color (impart color to product)	Colorless
Stability	GLP tested to 1 year under warehouse conditions; In-house stability monitored supporting 10 years stability. Prolonged storage under warehouse conditions did not significantly alter stability
pH of product	1.4-2.0
Freeze/thaw stability (0-25C)	N/A, similar properties as water
Crystallization, freeze, & pour points > 0C	N/A. similar properties as water

Interactions

Compatibility with other ingredients	<p>Incompatible with: Al sulfate, Al ammonium chloride, Al orthophosphate, chlorides, sequestering agents designed to remove transition metals from solution, EDTA (above 1.5%), calcium hardness above 300 ppm, prolonged light (UV) exposure.</p> <p>Ionic silver rapidly reacts with sulfides, chlorides and some other anions that will result in low solubility silver salts.</p> <p>Insoluble silver salt is much less potent than the ionic form. Roughly 1µg/mL (1ppm) chloride will bound 3µg/mL (3ppm) silver. Tap water may contain 50-100ppm chloride. Saline contains close to 5900ppm chloride. Residual chloride in paper and cotton products can bind ionic silver (about 1.2mg silver/g paper).</p> <p>Number of silver salts, such as nitrate, fluoride, acetate, sulfate and nitrite have high solubility (over 1 g/Lit) and do not present problems.</p>
Partitioning into oil/aqueous phase	Because SDC is water based, if combined with an oil based matrix separation will occur.
Corrosivity	Non-corrosive

Monitoring

Product/active detection	ICP, HPLC, Ion selective electrode; Titration
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Patents

US Patent # 6,197,814; #6,583,176 ; #6,890,953; #7,261,905; #7,435,438;
#7,601,755; #7,732,486; #7,763,297; #7,803,407; #8,399,003;
#8,568,757; #8,563,021

Supplemental and Use patents filed; International patents filed

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