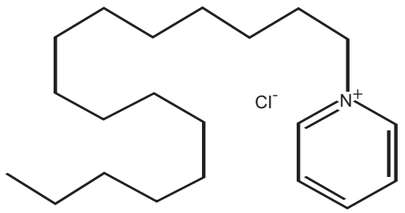
Effectiveness of CPC against Bacteria and other Microbes

CPC (Cetylpyridinium chloride or 1-hexadecylpyridinium chloride) is a quaternary ammonium compound which demonstrates varying degrees of activity against bacteria. Compared to other antimicrobials, CPC is especially effective against Gram-positive bacteria.



The following list summarizes the broad antimicrobial features of CPC, based on lethal concentrations:

Gram-positive bacteria (e.g. *Staphylococcus*):	highly sensitive
Gram-negative bacteria (e.g. *Salmonella, E. coli*):	moderately sensitive*
Mycobacteria (e.g. *Mycobacterium tuberculosis*):	insensitive
Bacterial spores (e.g. *Bacillus, Clostridium*):	insensitive
Fungi (e.g. *Candida, Saccharomyces*):	sensitive
Enveloped viruses (e.g. HIV, Hepatitis B):	sensitive
Non-enveloped viruses (e.g. Poliovirus):	insensitive

* note that several species of *Pseudomonas* are relatively insensitive.

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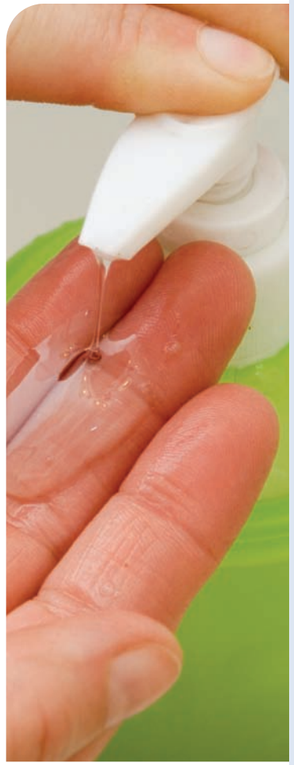

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Effectiveness of CPC against other microbes

CPC is effective against other microbes, mostly yeast-like and filamentous fungi. CPC is typically effective at a use level of approximately 14 mg L^{-1}. In use, the antifungal effects of quaternary ammonium compounds such as CPC are generally regarded as fungistatic.

It is generally accepted that CPC, as well as other quaternary ammonium compounds, are less effective against viruses without an outer envelope (bacteriophage F116 and human non-enveloped viruses such as the human enteroviruses and rhinoviruses) than to enveloped viruses (Herpes viruses, HIV and hepatitis B virus).

Micro-organism	Minimum lethal concentration	Source
Candida sp. (yeast-like fungus)	17-33	Sykes
Candida albicans (yeast-like fungus)	8	Giuliana
Saccharomyces cerevisiae (yeast-like fungus)	2	Giuliana
Torulopsis glabrata (yeast-like fungus)	8	Giuliana
Trichophyton sp. (mold-like fungus)	17-33	Sykes
Bacteriophage F116 (non-enveloped virus)	500	Maillard

All values are expressed to the nearest whole number, in mg L^{-1}.

Vertellus Health & Specialty Products LLC
300 North Meridian Street, Suite 1500
Indianapolis IN 46204
www.vertellus.com

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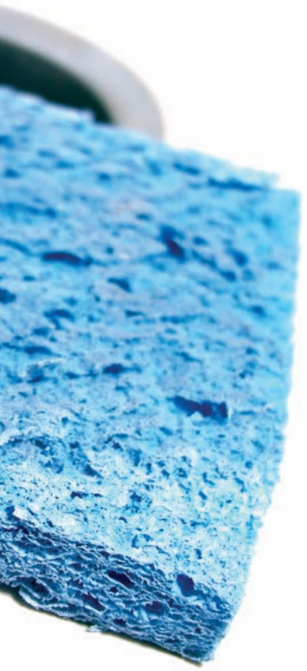

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Effectiveness of CPC against bacteria

The antibacterial properties of quaternary ammonium compounds have been known for nearly a century. A number of studies have demonstrated that CPC is active against many types of growing bacterial cells.

Gram-positive bacteria

CPC is effective against most of the common Gram-positive bacteria, such as a range of types of Staphylococci and Streptococci, including the pathogens *Staphylococcus aureus* and *Streptococcus pyogenes*. It is also reported to be effective against *Listeria* in foodstuffs. As a general rule, most actively-growing Gram-positive bacterial cells are highly sensitive to CPC and are rapidly killed (bactericidal) at relatively low concentration (at around 15 mg L^{-1}) and may be inhibited (bacteriostatic) at even lower CPC concentrations.

Mycobacteria

CPC is only effective against mycobacteria when used at high concentration. This specialized group of Gram-positive bacteria — which includes the pathogens responsible for tuberculosis and leprosy — has cells with tough, waxy walls which make them more difficult to inactivate. Mycobacteria are relatively insensitive to the effects of most quaternary ammonium compounds, including CPC.

Spore-forming (Gram-positive) bacteria

CPC and similar quaternary ammonium compounds are not effective in killing bacterial spores; however, they can be highly effective in preventing their growth. CPC is *sporistatic* rather than *sporicidal* since it inhibits the outgrowth of the bacterial spore during germination.

Gram-negative bacteria

CPC is somewhat less effective against common Gram-negative bacteria than it is to Gram-positive bacteria. For most Gram-negative bacteria, the amount required is lower, at an average of 25 mg L^{-1}. A notable exception is *Pseudomonas*, a common aquatic environmental Gram-negative bacterium, which are especially insensitive to the effects of CPC, requiring up to 172 mg L^{-1} to provide a lethal concentration. It is generally recognized that Gram-negative bacteria are moderately sensitive to quaternary ammonium compounds, including CPC.

The effectiveness of CPC against Gram-negative bacteria can be enhanced through the use of a chelating agent, such as ethylenediaminetetraacetic acid (EDTA). A combination of 0.1% CPC with 0.1% EDTA is more effective against *Pseudomonas aeruginosa* than CPC alone.

CPC: Cetylpyridinium chloride

The following table shows typical data for the amount of CPC required either (i) to *kill* the target microbe (the minimum *lethal* (cidal) concentration, also known as the minimum bactericidal concentration, or MBC), or (ii) to *inhibit the growth* of the target microbe (the minimum *inhibitory* concentration, or MIC, required to prevent growth and cause bacteriostasis).

Micro-organism	Minimum lethal concentration	Minimum inhibitory concentration	Source
Staphylococcus aureus (Gram-positive bacterium)	5-12		Sykes
		34	Bereswill
		0.3	Prince
Staphylococcus albus (Gram-positive bacterium)	14		Block
Staphylococcus epidermidis (Gram-positive bacterium)		0.3	Prince
Streptococcus pyogenes (Gram-positive bacterium)	8-24		Sykes
		34	Bereswill
Streptococcus pneumoniae (Gram-positive bacterium)	11		Block
Streptococcus 'viridans' (Gram-positive bacterium)	24		Block
Enterococcus spp. [antibiotic-resistant] (Gram-positive bacterium)		< 1-2.5	Alqurashi
Corynebacterium diptheriae (Gram-positive bacterium)	16		Block
Mycobacterium phlei (Gram-positive mycobacterium)	667		Block
Mycobacterium spp. (Gram-positive mycobacterium)		5-50	Broadley
Bacillus spores (Gram-positive, spore-forming bacterium)	> 500		Russell
		3	Block
Escherichia coli [E. coli] (Gram-negative bacterium)	15		Sykes
		6800	Bereswill
Campylobacter spp. (Gram-negative bacterium)		68-136	Bereswill
Salmonella typhi (Gram-negative bacterium)	16-67		Sykes
Shigella spp. (Gram-negative bacterium)	17-20		Block
Proteus vulgaris (Gram-negative bacterium)	29		Sykes
Kelbsiella pneumoniae (Gram-negative bacterium)	20		Block
Helicobacter pylori (Gram-negative bacterium)		3	Bereswill
Aeromonas spp. (Gram-negative bacterium)	1-50		Goñi-Urriza
Pseudomonas aeruginosa (Gram-negative bacterium)	172		Block
		> 500	Tattawasart
	14	500	Tattawasart
Pseudomonas stutzeri (Gram-negative bacterium)		25-100	Tattawasart
	4-6	25-50	Tattawasart
Pseudomonas putida (Gram-negative bacterium)	50	75	Edghill
Pseudomonas tolaassi (Gram-negative bacterium)	> 100	> 50	Wong

All values are expressed to the nearest whole number, in mg L^{-1}.

It should be noted that the data have been derived from a number of studies by various researchers using different methods and procedures, so the exact values for MBC and/or MIC may not be directly comparable in all instances.