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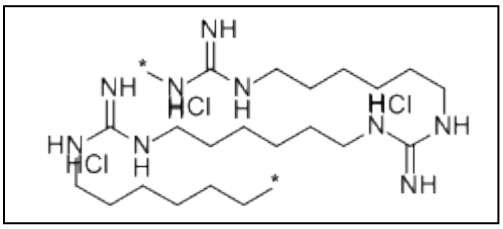
Antimicrobial Efficacy of PHP37 – A Review of Literature

Pure Global Solution is marketing PHP37 as an antimicrobial formulation. It consists of Poly Hexamethylene Guanidine Hydrochloride as an active ingredient which is a member of the polymeric guanidine family. It has molecular formula of C21H45N9X2.3ClH with molecular weight of 533.032 g/mol and CAS: 57028-96-3.
It is a non-corrosive, odorless, colorless, broad-spectrum disinfecting product which can be readily diluted in water. The formulation has been reported to be equally effective against broad range of microorganism including gram-positive and gram-negative bacteria, fungi, cyanobacteria/algae and viruses.



Toxicity profile (six—pack) of the PHP37 was studied by the NSF International according to the guideline 423 of the Organization for Economic Co-operation and Development (OECD). The OECD is the world-class standard of acceptance in exposure assessment of chemicals on human health and the environment. Their guidelines are the accepted standard in more than 37 countries worldwide and the United States - OECD. The toxicity studies using 0.08% of the PHP37 formulation established acute oral toxicity at LD50 >5000 mg/kg and acute dermal toxicity at LD50 > 2000 mg/kg of body weight, which is considered as non-irritating (NSF International report number 4706-RAI-254-18.

EFFICACY TESTS

In a study, the efficacy of PHMGH was tested against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella choleraesuis*, methicillin-resistant *S. aureus* (MRSA) and *Escherichia coli* using the AOAC method. The phenol coefficient values of PHMGH were determined to be 7.5, 6.1 and 5, for *S. aureus*, *Salmonella choleraesuis and P. aeruginosa*, respectively. MRSA and *E. coli* were killed by PHMGH at concentrations as low as 0.04 and 0.005 % (w/v), respectively, within 1.5 min. The PHMGH molecule appears to compromise the integrity of cell envelope causing leakage of cell content (Oule et al., 2008).

In another study, the efficacy of PHMGH was compared with hydrogen peroxide and sodium hypochlorite against *S. aureus, E. faecalis, E. coli and P. aeruginosa* isolated from toilets. For these bacteria the MIC values of PHMGH were 0.047%, 0.047%, 0.047% and 0.0934% respectively while the MIC values of hydrogen peroxide were 0.0934%, 0.0934%, 0.186% and 0.0934% respectively whereas the MIC values of sodium hypochlorite for all these bacteria was 0.0934%. In terms of antibacterial efficacy, PHMGH was more effective against *S. aureus, E. faecalis, E. coli* when compared with hydrogen peroxide and sodium hypochlorite (Figure 1) (Ahmed and Mashat 2015).

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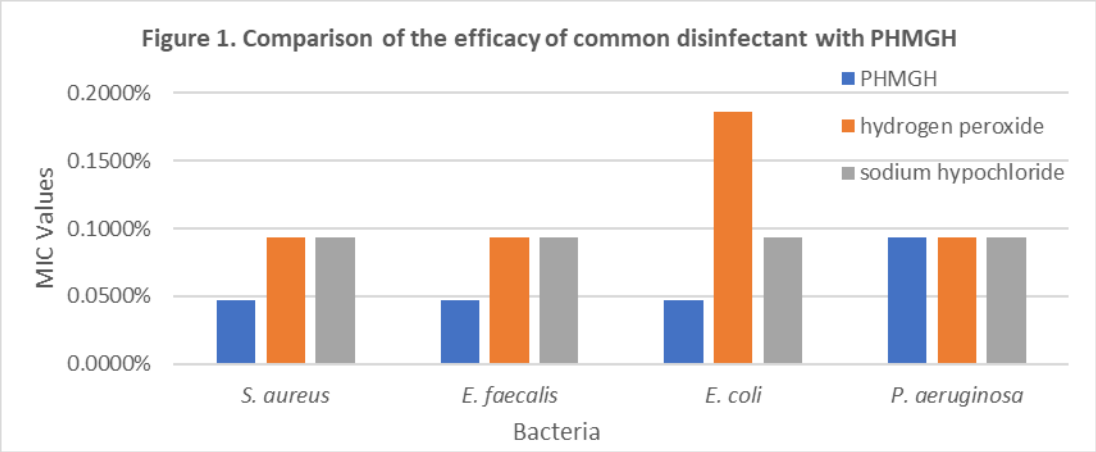

MIC: Minimal Inhibition Concentration

The antifungal activity of PHMGH for cocoa beans isolates (five reference strains of pathogenic bacteria and six strains of fungi). The Minimal Inhibition Concentration (MIC) reported were between 0.01 and 1.9 mg/ml and equal to the Minimal Bactericidal Concentration (MBC) or Minimum Fungicidal Concentration (MFC) regardless of the strains of those microorganisms. The bacteria were more sensitive to PHMGH than were the fungi. *Enterobacter cloacae* was the most sensitive bacterium with a MIC and MBC of 0.01 mg/ml, whereas the genus Aspergillus was the least susceptible of the microorganisms tested, with a MIC and MFC from 1.0 to 1.9 mg/ml. The time required for the activity of PHMGH varies from 2 min for bacteria such as *Enterobacter cloacae* to 12 min for fungi such as *Aspergillus tamarii* and generally increases with the MBC or the MFC. Through this *in vitro* study, the PHMGH has been proved to be bactericidal and fungicidal on the strains studied. Hence, it could probably serve as a fungicidal disinfectant for the treatment of cocoa beans after harvesting.

Table 1: Minimal Inhibition Concentration (MIC) of PHMGH for varies microorganisms

Organisms	MIC (mg/mL)	Organisms	MIC (mg/mL)
E. cloacae	0.01	*A. corymbifera*	0.4
Salmonella Typhi	0.04	*P. chrysogenum*	0.7
K. pneumoniae	0.04	*A. tubingensis*	1.0
B. subtilis	0.04	*A. flavus*	1.0
S. sonnei	0.07	*A. tamarii*	1.9
R. oryzea	0.4		

The sporicidal activity of a PHP37 analogue - Akwaton, which is a polyhexamethylene-guanidine hydrochloride (PHMGH)-based disinfectant, was tested against *Bacillus subtilis* spores in water and on solid surfaces (stainless steel and glass). In water environment, PHMGH

at 0.06% was found to be sporostatic and at 0.08% its was sporicidal. At 0.24 % concentration, PHMGH killed 100% of *Bacillus subtilis* spores within 3 minutes. Whereas it took 90 second for 0.44% solution of PHMGH to kill100% of spores in water. Bacteria on solid surface required slightly higher concentration of PHMGH to achieve similar results. On stainless steel/glass 100% of *Bacillus subtilis* spores were killed within 3 minutes and 90 seconds by 0.52% and 0.36% of PHMGH solution, respectively. The results of this study indicate the potential of PHMGH as sporicidal disinfectant (Oulé et al., 2012).

Studies conducted at the National Science Foundation Center for Water and Environmental Technology at Arizona State University has shown the algacidal and bactericidal capabilities of the PHP37 formulation. Addition of 0.05% PHP37 in water resulted in 99.4% reduction in green algae and >99.99% reduction in Cyanobacteria within 48-hour of application (Abbaszadegan and Alum 2019).

The surface disinfection studies using 0.05% PHP37 resulted in a minimum of 3 log of *Pseudomonas aeruginosa* after fresh application. The residual effect of PHP37 after 48 hours on *Pseudomonas aeruginosa* resulted in 2 log reduction.

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