Sky™ Home Innovations

QUANTUM DISINFECTION™

Scientific Evidences

QUANTUM DISINFECTION™

What is it?

Quantum Disinfection™ (QD) is a new technology that uses the quantum mechanic principles of electron movement to create catalytic active surfaces (positively charged) that can disintegrate any microorganism instantly, upon contact.

In more detail, QD refers to (1) a technology that allows the creation of (2) new composite materials with (3) particular disinfection capacities:

- (1) The QD technology uses the general principals of the “Doping” technique, recently discovered in the filed of advanced semiconductors, coupled with the high disinfection proprieties of cationic Silver;
- (2) The QD media represents alumina based ceramics (fig. & tab. here bellow) tuned with one layer of titanium dioxide (called Acceptor Support) and another layer of silver (called Active Phase). These two layers influence each other and create at the alumna surface a strong cationic filed, + 1.4 eV (called Active Surface);
- (3) The QD phenomenon is related to the disintegration of the microorganisms that touched the Active Surface of the QD media. The strong cationic filed attracts and rips of the electrons from the external membranes, enzymatic layers or DNA reproducible sequences of any microorganism that get into a direct contact with the QD media.

Quantum Disinfection™ Media in a Petri dish

Quantum Disinfection™ media general characterization

Characteristic	Value
Chemical composition	Al_2O_3 - TiO_2 - Ag
Shape	Sphere
Particle Size (mm)	Diameter: 1 - 3
Particle size repartition (%: ball size)	90 - 95%: 1.9mm <5%: 1.1mm <5%: 2.9mm
Average particle size (mm)	1.9
Recommended Mesh Size (mm)	0.40
Apparent density (g/cm^3)	0.75

A more detail description of the Quantum Disinfection™ can be found in the following related Claire’s patents:

- WO2013007289 (A1)
- EP2729001B1
- CN103997890A
- CN103997890B
- US2014120148 (A1)
- US2016257583 (A1);
- US9650265 (B2);
- CN106830232 (A)

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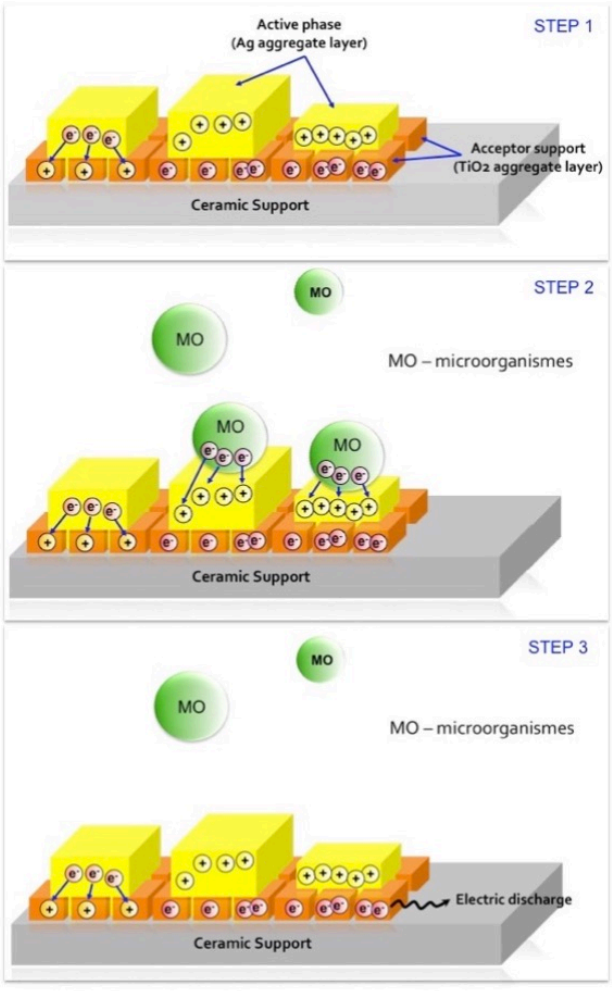
How does it work?

Obviously, the germicidal capacities of the QD media are acquired due to the presence of the silver at their surface. In the same time, besides the efforts of the scientists from all over the world, the action mechanism of silver against microorganisms remains is not entirely understood. Our hypothesis for our QD silver based product is the following:

The silver at the QD surfaces is in a high cationic state (1.4 eV). This electron discharge is achieved due to the presence of the TiO_2 layer which, in the QD spacial spatial arrangement, size and bonding level, influence the Ag layer as follows: the big cation Ti^{4+} of the TiO_2 (the layer called “Acceptor Support”), attracts closer to it the electrons from the silver above (Step 1, fig.). Due to the Ag high conductivity capacities, this effect migrates through the silver aggregates up til their surfaces. As a consequence, the surface of the QD media found itself in lack of electrons and acts just like a discharged active field powerful enough to ripoff the electrons (e-) from any microorganisms with which it comes into a direct contact (Step 2).



Moreover, once removed for the microorganisms (MO), the e- are instantly released in the water, without no influence on the electron discharged field at the surface of the QD media (Step 3). This catalytic behavior induce a permanent germicidal activity ensuring that no microorganism can stay alive once in contact with Quantum Disinfection™ media.

As a conclusion, the QD electron discharged field causes the entire structure of the microorganisms to collapse at the quantum level, instantly, at contact. TPC measurements confirm the bacteria (*E. coli*) DNA is also instantly destroyed in this electron exchange.

Any microorganism that touches the Quantum Disinfection™ media is ceases to exist completely.

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Are there any scientific evidences?

Several results can be considered as support for the Quantum Disinfection™ principals, as described on the previous page. These data can be regrouped in two main categories:

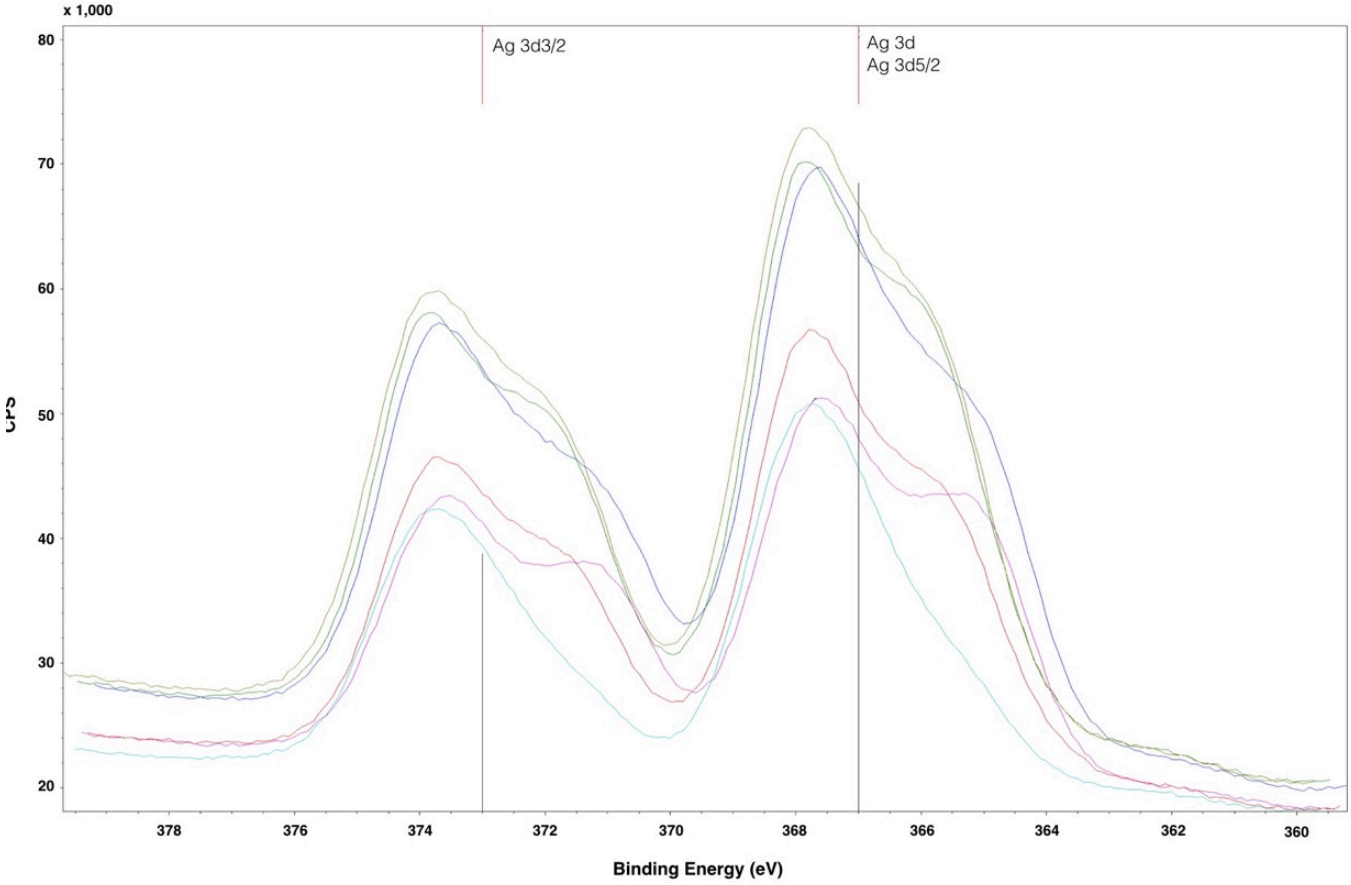
1. QD media characterization:
   - 1.1. XPS analysis;
   - 1.2. SEM imegery;
   - 1.3. Silver Leaching.
2. QD media effects on the microorganism:
   - 2.1. TEM imagery;
   - 2.2. Germicide Efficiency;

All the scientific evidences are published in different reports, patents or scientific papers available upon request. A short resume of each one is presented in the following pages.

1. QD MEDIA CHARACTERIZATION

1.1. XPS analysis

The Ag cationic surface state, responsible for the disinfection effect, of Quantum Disinfection™ X3 was evaluated by X-Ray Photoelectron Spectroscopy (XPS) Surface Analysis. The results are presented in the following figure:



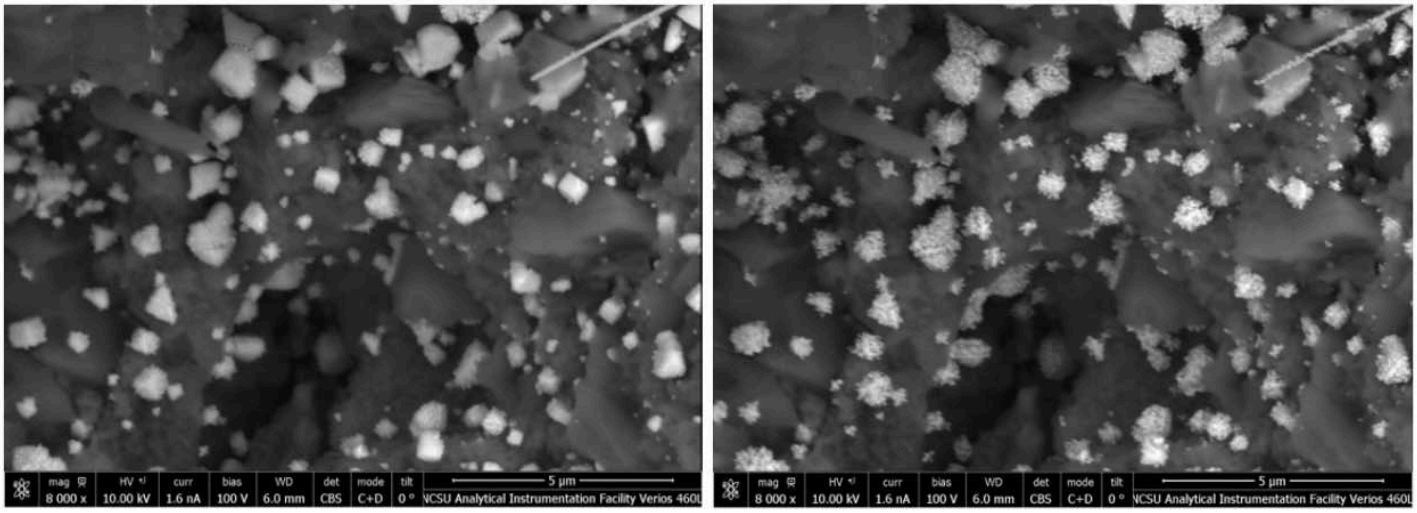
In compounds like AgO, Ag_2O or AgC (Ag oxidation state: +1), the emission range of silver 3d for both 3/2 and 5/2 is generally detected at 367 and 373 eV respectively. The two peaks found in all 6 analysis of the same Quantum Disinfection™ sample are clearly defined at 367.9 and 365.8 eV respectively. This differential charge can be the effect of a known phenomenon occurring when there is an insulating or semi-conductive material (like our TiO_2) in contact with a conductive material (like our Ag). This phenomenon is the most logic explanation why these two peaks are displaced at higher bonding energy values. As the peak-to-peak distance between these two components is perfectly conserved, we can calculate the exact oxidation state of the silver at the sample surface: **+1.48** (acceptable margin of error: 0.1 eV).

1.2. SEM imegery

The powerful electron discharged field at the surface of the Quantum Disinfection™ media was observed by special tests on Scanning Electron Microscope (SEM analysis) realized in collaboration with North Carolina State University.

Under the electron beam of the microscope, the surface of the silver aggregates metallize *in situ*, giving rise to small aggregates (50 nm in average) that covered completely their original smooth surface. This metallization is due to the interaction between the Ag+ and the SEM beam electrons.

In function on the quantity of electrons absorbed by μm^2 of surface per second, the number of Ag active cationic sites can be approximatively calculated.



Surface morphology of the QD media (SEM imagery):
initial state (left); metallic state 55 seconds after exposition to the SEM electron beam (right)

Knowing that the media has been exposed to an electronic potential of 15.0 kV for 55 seconds, the electron discharge of the surface cations can be estimated at $2x10^9$ e-/μm^2.

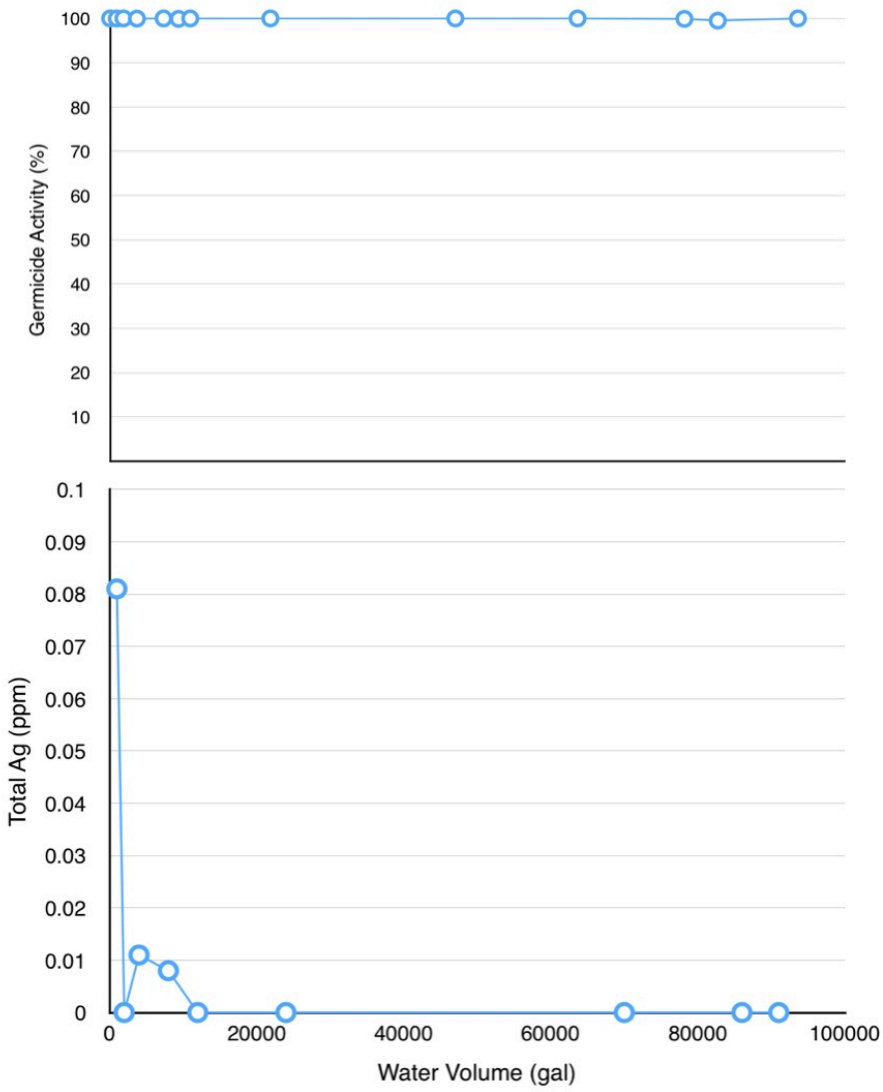
At our best knowledge, no other material with such a cationic surface state has yet been identified in specialized literature.

1.3. Silver Leach

The Silver leached in the downstream water, after touching the Quantum Disinfection™ media, is constantly measured and intensively studied at Claire Technologies. All these data are available upon request.

In addition, several certification institutions (NSF International, IAMPO), private laboratories (Avazyme, QFT Laboratory) and government organizations (US EPA) also measured and test the Ag leach from the QD media. All their reports are available upon request.

In general, if the QD quantity / Water flow report is respected, all results show the same leaching behavior (example in the figure bellow):



Evolution of the Total Silver concentration in function of water volume that passed through the QD unit (Quantity of QD media: 250g; water flow: 7 GPM)

The Total Ag evolution follows accurately the same path: an important quantity released at the beginning of the test and than, a smooth linear decrease that gradually, reaches undetectable levels. During all test periods, the germicide activity remain unchanged at 99.99%.

All results allowed to conclude that:

- there is no correlation between the leached silver and the germicide properties of the QD media: in several cases, especially high flows, the Total Ag was undetectable and the Germicide Activity of the QD media was 99.99%;
- the Ag leached in the downstream water is the AgCl dust that cover the porous surface of the QD media during the manufacturing process: the exponential decrease of the silver concentrations is a direct indicator that these silver particles are washed away;
- the AgCl leached particles have no germicide activity, are completely inert with no impact on human health or environment;
- all the detected Ag concentrations are under the EPA Drinking Water Standards and Recommendations (e.g. 0.1 ppm). This statement is proved by the following Certifications:

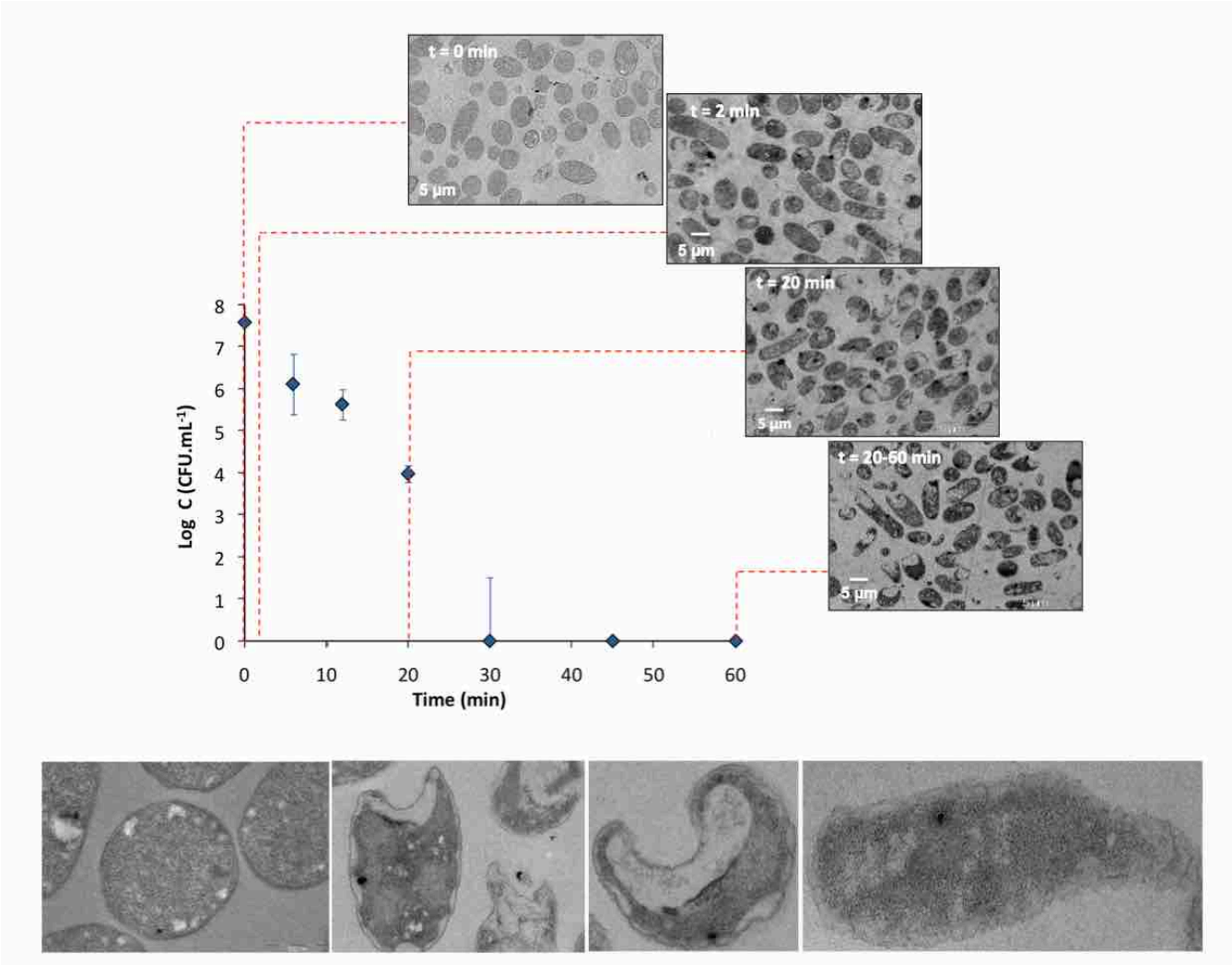
Certification	Total Ag concentration (ppb)
NSF/ANSI 42 Certificate # C0292640-01	5
IAPMO - NSF/ANSI 61 Certificate #: 23033	43
MOH - China Certificate #: 2015KF2513	< 5

2. EFFECTS ON THE MICROORGANISM

2.1. TEM imagery

Transmission Electron Microscopy (TEM) observations were conducted to visualize the morphological changes of *E. coli* cells after the contact with the QD media. The first image here bellow presents a TEM micrograph of the initial bacteria with integer cell membrane contours and a relatively uniform electronic density within the cell (darker areas), revealing the normal bacterial state. The images bellow show TEM micrographs of bacteria after 2, 20 and 60 minutes of contact with only 1 gram of QD media.

After the first few minutes of direct contact with the germicide ceramic surfaces, significant morphological changes of shape and integrity occurred in the *E. coli* cells. The enormous leak of electrons can be clearly observed all around the bacteria cell surface, especially in places that we consider the contact point with the ceramics, resulting in the rupture of the cellular membrane and leakage of the intracellular compounds.



TEM analysis: integer E. coli cells (first image) & E. coli cells after being in contact with the QD media (2nd, 3rd and 4th images)

2.2. What microorganism it can kill?

The germicidal capacities of the Quantum Disinfection™ media are intensively tested at Claire Technologies Microbiologic Laboratory using *Escherichia coli* streams. At least, 3 years of data are available upon request.

Meanwhile, several institutions and certified laboratories tested the QD media in the last 5 years. Their results are presented in the following reports also available upon request:

- Environmental Protection Agency (EPA - USA);
- Guangdong Detection Center of Microbiology (GDCM - China);
- Institute for Environmental Health and Related Product Safety, Chinese Center for Disease Control and Prevention (IEHRPS - CCDCP - China);
- Avazyme (USA);
- Eurofins (France, USA);
- Microbac (USA);
- Proteus (France);
- Ackuritlabs (USA);
- University of Wisconsin (USA);
- QFT Laboratory, LLC (USA);

A regroupment of all results is presented in the following table:

Microorganism (MO)	**MO type**	**Best germicide efficiency (log reduction/100ml)**	**Certified Laboratory**
Pseudomonas aeruginosa	bacteria	log 7	PIL, Proteus
Escherichia coli		log 7	EPA, Avazyme, Eurofine, Microbac, Proteus, Ackuritlabs, GDCM, BFML
Staphylococcus aureus		log 7	PIL, Proteus, BFML
Eterococcus hirae		log 10	Ackuritlabs, PIL, Proteus
Legionella adelaidensis		log 6	Proteus
Citrobacter sp		log 5	PIL
MS2	virus	log 6	Avazyme, QFT Laboratory
Candida albicans	yeast	log 5	Proteus
Anabaena constricta	algae	log 5	Proteus
Cryptosporidium	protozoa	log 5	Eurofines