Claire Technologies

QUANTUM DISINFECTION

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What is it?

Our products are represented by innovative systems for the disinfection of different types of atmospheric mediums (water, air, oil, etc.), composed of 2 basic parts:

1. The Quantum Disinfection ceramics with germicide surfaces.
2. The disinfection device that contains these ceramics (see last page).

Activated Ceramics with Germicidal Surfaces

Quantum Disinfection is represented in three dimensional silicates (SiO2) or, spheralite alumina (Al2O3), both ceramics with a large surface area. These high-purity ceramics offer a perfect catalyst support material for our technology. Moreover, the Quantum Disinfection ceramics can be arranged in made-to-order characteristics such as shape (cylindrical trilobite extrudes, balls, particles, etc.), size (350 µm - 4 mm), interior pore diameter, or other surface properties according to the application and operator specifications.

Due to our technological breakthrough (US Patent 62/128,160), the surface of the X3 ceramic supports was modified with one layer of proprietary aggregates, and above it, one layer of silver aggregates. Each substance has its specific role and they are covalently bonded to one-another. Those layers give Quantum Disinfection ceramics very powerful surface properties which express as high germicidal capacities.

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How does it work?

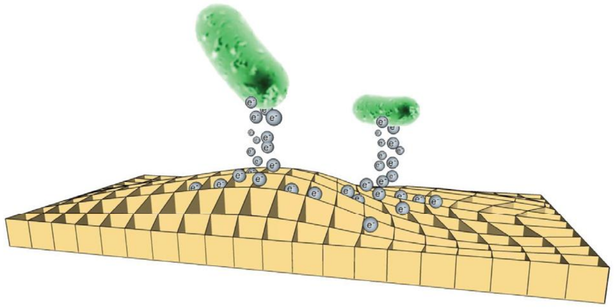
The germicidal capacities of the X3 ceramic composite materials are acquired due to the silver aggregates present at their surfaces. In spite of scientific research from across the world, the germicide activity of silver remains unclear. Our hypothesis for our silver based product is the following:

Germicide surfaces of the modified ceramics can have powerful electronically discharged areas that can destroy microorganisms with which it comes into direct contact, and with an efficiency exceeding, in some cases, 99.9999%. This electronic surface discharge is achieved by the presence of the two aggregate layers which in certain spatial arrangements, may influence each other. The first “Acceptor Support” layer attracts and discharges the electrons from the “Active Surface” layer (Step 1).

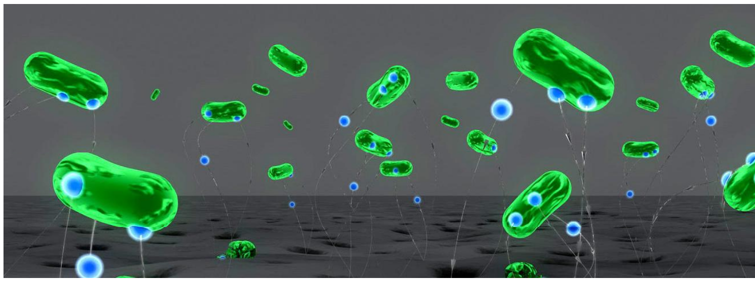
(Step 2) The surface of this last layer now lacks electrons and to restore its balance it removes electrons from microorganisms upon contact.

(Step 3). Once electrons, which are permanently attracted from the Active Surface and partially stored in the “Acceptor Support” layer, become sufficiently charged, the electrons are released in forms of very small electric currents. This discharge renews the electron attraction from the upper layer ensuring the continuous activation of the surface.

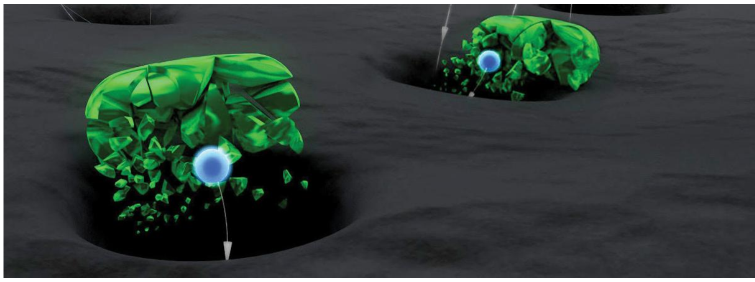
This “catalytic” behavior is translated by a permanent germicidal activity to ensure that no microorganism can resist once it contacts the surface. This whole action happens without any external excitation (UV light, heat, electricity, etc.).



Step 1 Acceptor Support layer attracts electrons



Step 2 Microorganisms come in contact with the surface



Step 3 Microorganisms are eliminated and discharged

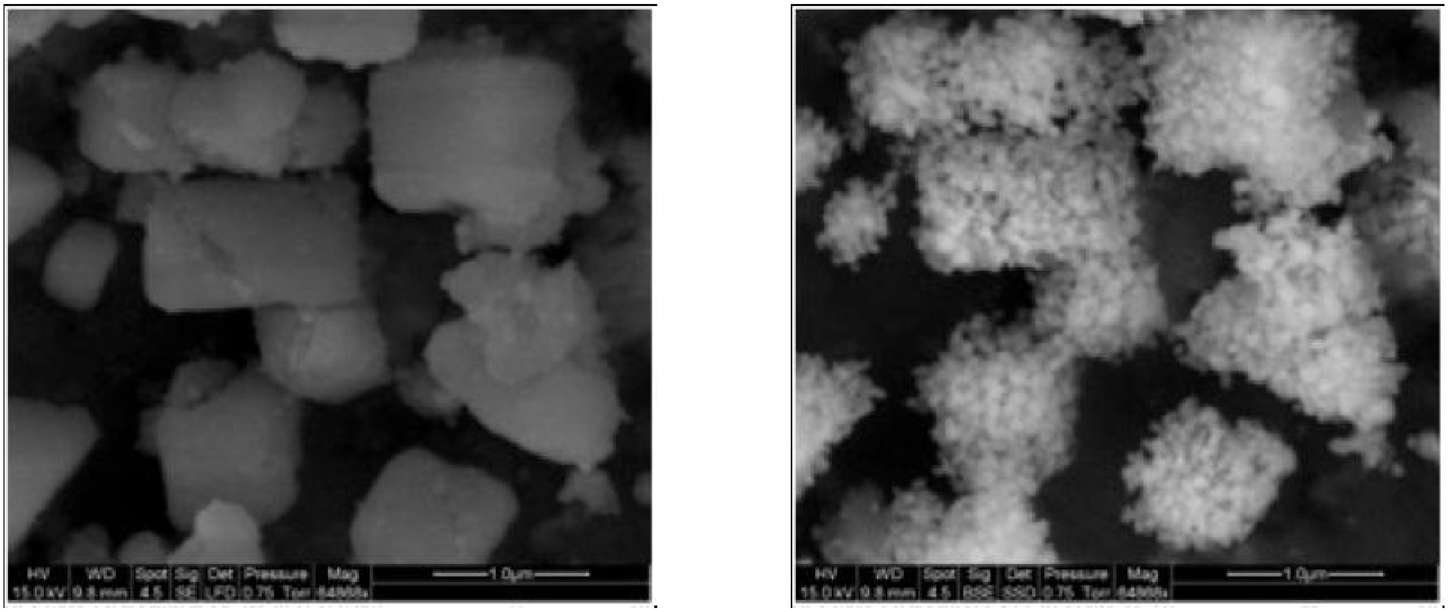
In other words, as microorganisms come into direct contact with the X3, the electrons inside the pathogens are irretrievable attracted by the positively charged surface. This causes the entire structure of the microorganisms to collapse on a molecular scale, with the electrons transferring immediately to the X3 surface. TPC measurements confirm the pathogen’s DNA is also instantly destroyed in this dense electron exchange. In less than 0.1 seconds, the pathogen ceases to exist completely.

SEM Evidence

Cationic surface state

The cationic surface state responsible for the disinfection effect of activated ceramics was evaluated by special tests on a Scanning Electron Microscope (SEM analysis). Under the electron beam of the microscope, the product surface metalizes in situ, giving rise to nano-aggregates (average 50 nm) that cover completely its original smooth surface. This metalization is due to the interaction between the surface powerful cationic sites and the SEM beam electrons.

We calculated the number of active cationic sites depending on the quantity of electrons absorbed by ^{2} of surface



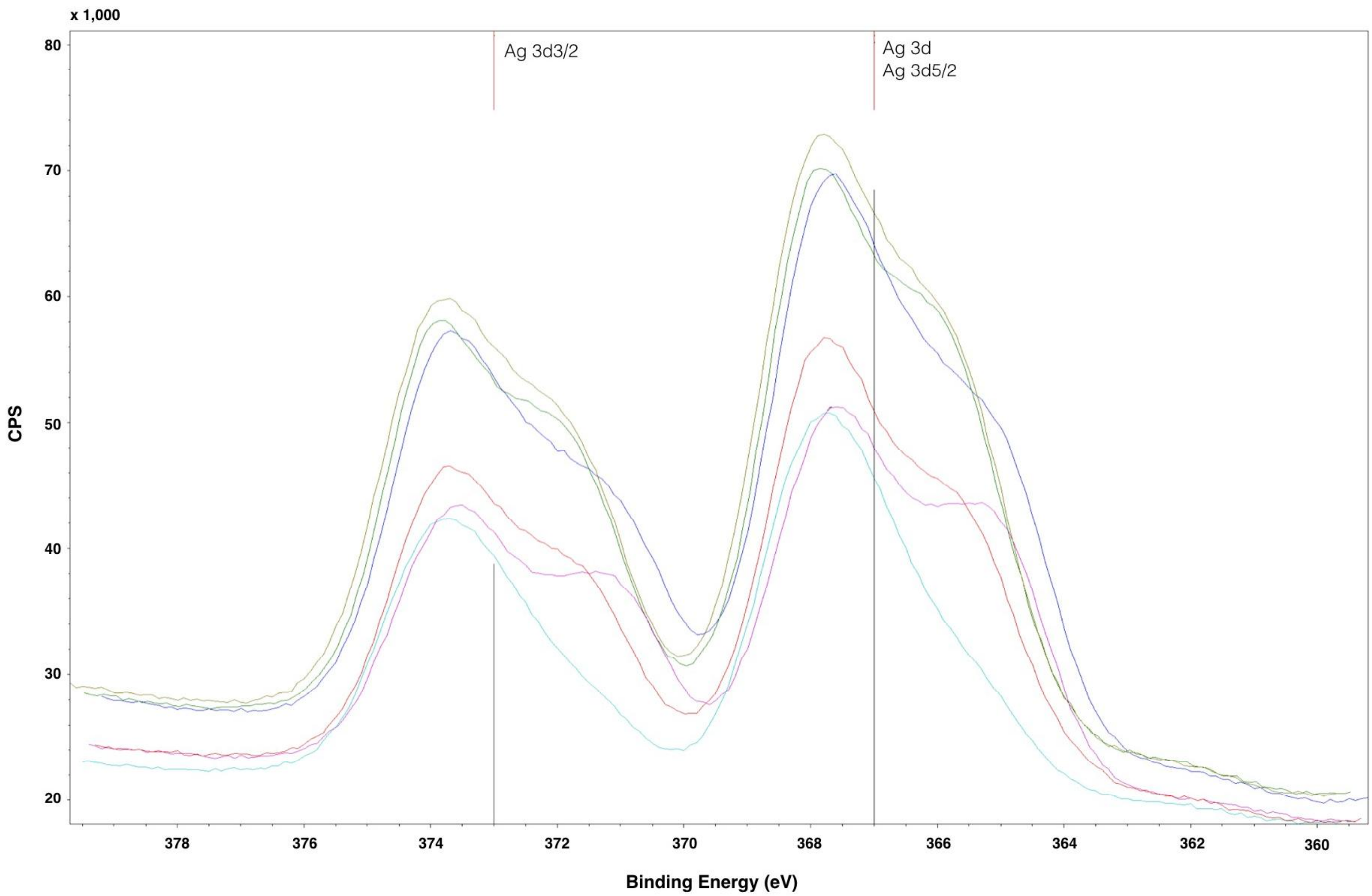
Evolution of the cationic surface state of the X3 ceramics:
Initial state (left) metalized 55 seconds after exposition to SEM electron beam (right) (SEM pictures).

Knowing that the product has been exposed to an electronic potential of 15.0 kV for 55 seconds, the electronic discharge of the surface cations is estimated at 2 x 109 electrons / μm^2. At present, no other material with such a cationic surface state has yet been identified in specialized literature.

XPS Evidence

Cationic surface state of the X3

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



Ag 3d oxidation state of X3 (XPS spectra): 6 times

In compounds like AgO, Ag2O or AgC (Ag oxidation state: +1), the emission range of silver 3d for both 3/2 and 5/2 is generally at 367 and 373 eV respectively. The two peaks found in all 6 analysis of the same X3 sample are clearly defined at 367.9 and 365.8 eV respectively, outside the classical range. This differential charge, a phenomenon occurring when there is an insulating or semi-conductive material (like our TiO2) in contact with a conductive material (like our Ag) these two peaks can be 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 surfaces: +1.48 (acceptable margin of error: 0.1 eV).

Testing evidence

Cationic surface state

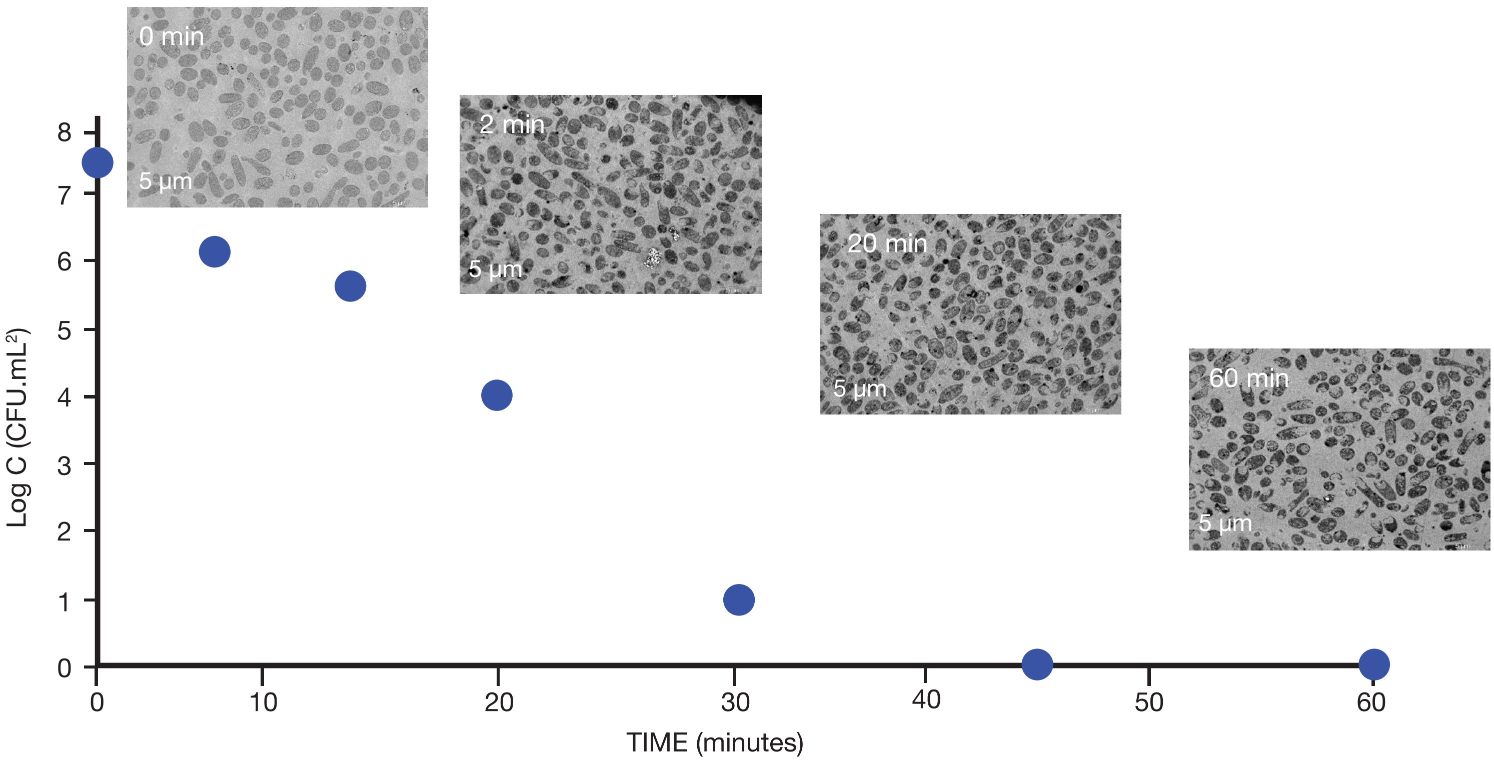
According to the BS EN 1276 Antiseptic and Disinfectant Standards, X3 “is considered as a disinfectant, any product that has the ability to reduce by 10E+5 (5 log) the number of viable bacterial cells belonging to referenced strains of Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus and Enterococcus hirae” (Art. 3.3-Bactericidal Activity, page 6).

Several institutions such as Environmental Protection Agency (EPA - USA), Pasteur Institute of Lille (PIL - France), Microbac (USA), Proteus (France), Ackuritlabs (USA), Guangdong Detection Center of Microbiology (GDCM - China) and The Byrraju Foundation Microbiological Laboratory (BFML - India) tested the X3 ceramics according to the BS EN 1276 Standards and our applications. The obtained results are shown in the tables below.

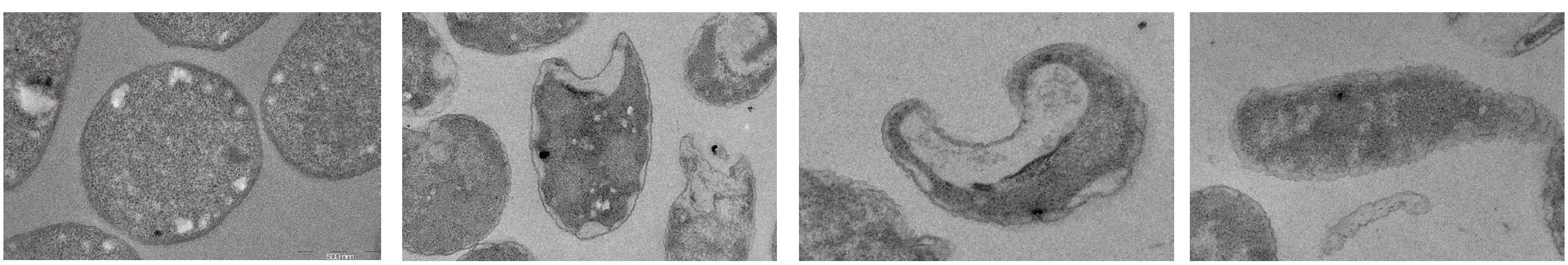
Microorganism (MO)	**MO Type**	**Best germicide efficiency (log reduction)**	**Certified Laboratory**
Pseudomonas aeruginosa	Bacteria	log 7	PIL, Proteus
Escherichia coli		log 7	EPA, PIL, Microbac, Proteus, Ackuritlabs, GDCM, BFML
Staphylococcus aureus		log 7	PIL, Proteus, BFML
Eterococcus hirae		log 10	Ackuritlabs, PIL, Proteus
Legionella adelaidensis		log 6	Proteus
Citrobacter sp		log 5	PIL
Candida albicans	Yeast	log 5	Proteus
Anabaena constricta	Algae	log 5	Proteus

Bacterial disintegration on the Activated X3 surface

Transmission Electron Microscopy (TEM) observations were conducted to visualize the morphological changes of E. coli cells during contact with the X3. The first image above 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 without any contact with the activated ceramics. The images bellow show TEM micrographs of bacteria after 2, 20 and 60 minutes of contact with only 1 gram of X3.



After the first few minutes of direct contact with the X3 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 at the contact point with the X3, 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 2 min contact with the X3 (2nd, 3rd and 4th images)

Other effects besides disinfection

COD removal

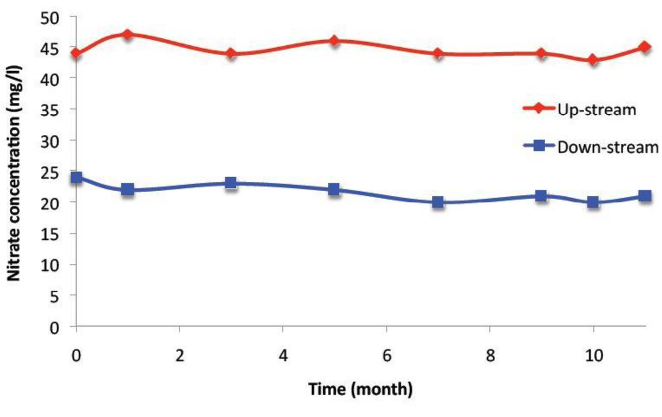
During our case studies on the decontamination of the wastewater from treatment plants, we noted that the Chemical Oxygen on Demand (COD) can be removed with an amount that reaches, in some cases, 82 %, especially when the upstream COD concentration is quite low (e.g. 30 mg/l average). Normally, these removal performances are usually obtained with very intensive and high-performance process (e.g. advanced oxidation, etc.).

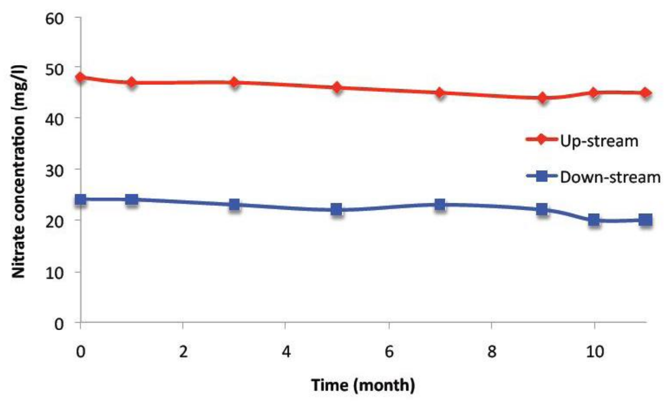
N-NH4 removal

We observed that ammonia and nitrates are also removed from the treated water (wastewater and hot tub water observations) with a 40 to 77% efficiency. Just like in the case of the COD removal, these performances were unregistered with low initial concentration of NH4 (0.5 - 40 mg/l).

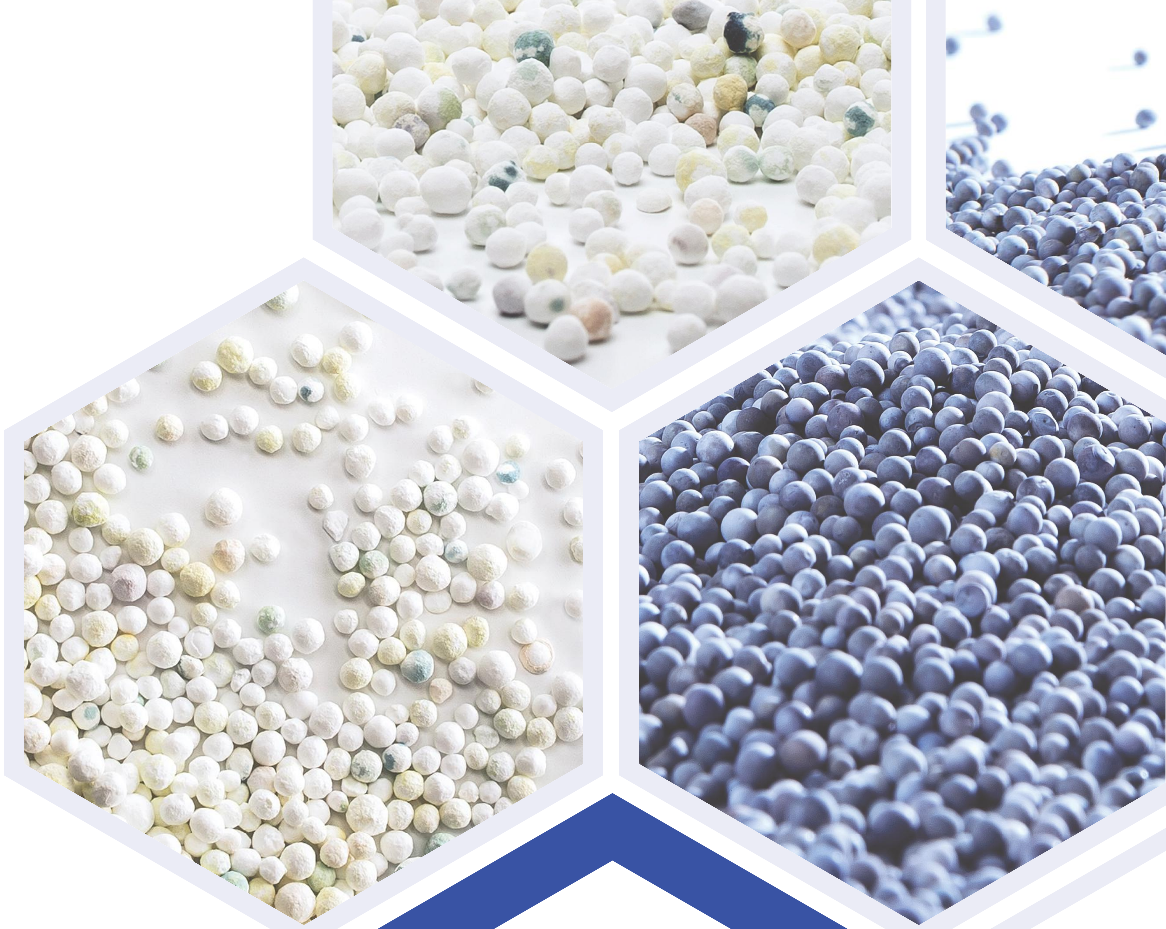
The only logical explanation that we found is that the surfaces of the X3 have, indirectly (through the OH° radical formation), reduction capacities and in cases where the initial concentration of ammonia, for instance, are low, those traces can be removed through the following reactions:

$Ag^+ + H_2O \longrightarrow OH^- + H^+$
$Ag^+ + OH^- \longrightarrow OH°$
$OH° + 2NH_4 \longrightarrow N_2 + 3H_2 + H_2O + H^+$





Nitrates removal by the X3 ceramics at: Mogallu (left) and Kommara (right) Drinking Water Treatment Plant (India)



Partnering with

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