Introduction.

A non-toxic, low-corrosive, biodegradable aqueous formula with enhanced physical stability for the rapid mitigation and decontamination of chemical, biological agents, and toxic hazardous materials. The basic chemistry of the formula is a combination of two active ingredients; quaternary amines and hydrogen peroxide. The formula also contains several stabilizing compounds, which help to extend the shelf life of the formula and control the chemical reaction, so that the decontamination occurs in a safe manner. Additional tests indicate that the formulation is effective as a decontaminant on several varieties of hazardous bacteria, viruses and materials such as hydrocarbon-based compounds as well.

The formulation allows decontamination of areas populated with both people and sensitive equipment; works on all currently anticipated material surfaces and can be incorporated into a wide variety of carriers (foam, gel, fog, aerosol) that satisfy a wide variety of operational objectives.

The formula works on the following:

- Chemical Warfare Agents (CWA)
- Biological Warfare Agents (BWA)
- Toxic Industrial Chemicals (TIC)
- Non-conventional Toxic Agents (NTA)
- Radiological and Nuclear particles

Neutralization is defined as the mitigation, de-toxification, decontamination, or otherwise destruction of toxants, to the extent that the toxants no longer cause acute adverse effects to humans or animals.

CWAs and TICs

Decontamination of chemical warfare agents (CWAs) and other toxicants such as nonconventional toxic agents (NTAs) or toxic industrial chemicals (TICs) can lead to troublesome stable and still highly toxic products. Water content, reaction time, temperature, order of addition, matrix effects, and/or pH have been shown to be critical parameters to controlling reaction paths in decontamination chemistry towards forming nontoxic products and avoid from forming toxic residuals.

Decontamination means the degradation of chemical warfare agents (CWAs) and other toxicants to levels that are significantly lower than the original concentration.

The formula addresses the need of neutralizing the adverse effects of **toxic industrial chemicals (TICs)**. A TIC is defined as any chemical compound, constituent, substance, species, or agent that through its chemical action on life processes can, if left untreated, cause death, temporary incapacitation, acute and chronic health effects, or permanent harm to humans or animals. This includes all such chemical agents, regardless of their origin or of their method of production; and regardless of whether they are produced in facilities, in munitions, or elsewhere.

The majority of the TICs can be neutralized by four reaction mechanisms:

1) **Chemical Oxidation.** Chemical oxidation is one half of a redox reaction, which results in the loss of electrons. One of the reactants in the reaction becomes oxidized or loses electrons; while the other reactant becomes reduced, or gains electrons. In Chemical oxidation, oxidizing compounds (compounds that give electrons away to other compounds in a reaction) are used to change the contaminants into harmless compounds.

The remediation of certain organic substances such as chlorinated solvents (trichloroethene and tetrachloroethene), and gasoline-related compounds (benzene, toluene, ethylbenzene, MTBE, and xylenes) by chemical oxidation is possible. Some other contaminants can become less toxic through chemical oxidation.

2) **Nucleophilic attack** is a fundamental class of reactions in which an electron nucleophile selectively bonds with or attacks the positive or partially positive charge of an atom or a group of atoms to replace a so-called leaving group.

3) **Chemical reduction** is a half-reaction in which a chemical species decreases its oxidation number, usually by gaining electrons. Reduction is the opposite of oxidation. A reduction reaction always comes together with an oxidation reaction. Oxidation and reduction together are called **redox.**

4) **Buffering reaction**. The formula can be considered as a buffer solution because of its aqueous solution, consisting of a mixture of a weak acid and its conjugate base. Because the acid and the base components do not undergo any reactions that significantly alter their concentration, both remain present in the solution. In addition, weak acid and its conjugate base only rarely react with water. However, they are very likely to react with any added strong base or strong acid. Its pH slightly changes when a small or moderate amount of strong acid or base is added to it. Thus, it is used to prevent changes in the pH of a solution. Buffer solutions are used as a means of keeping pH at a nearly constant value in a wide variety of chemical applications.

In addition to these four reaction mechanisms, the formulation exploits the principles of **cationic micelle catalysis** and the solubilization power of cationic hydrotropes to dissolve the sparingly soluble toxants. This principle is used for a TIC or a Chemical that is insoluble in water that may be detoxified by nucleophilic attack.

Selected constituents in the formulation provide this mechanism to solubilize sparingly soluble agents and enhance vulnerability to a nucleophilic attack. This is accomplished through the recognition that certain nucleophilic agents are negatively charged.

The insoluble chemical agent (or TIC) is dissolved within the micelle comprised of an aggregate of surfactant molecules with hydrophobic tails forming the interior core of the micelle, and hydrophilic heads concentrating at the surface of the micelle. These positively charged hydrophilic heads attract the negatively charged nucleophiles. In this sense, the cationic surfactant acts as a catalyst to speed up the reaction between the toxant and the reactive compound.

This principle can also be applied to insoluble chemical agents which are subject to an oxidative attack by a negatively-charged oxidizer and to insoluble chemical agent that are subject to a reductive attack by negatively-charged reductants.

For oxidative attack of a negatively charged water-soluble chemical agent or TIC: the agent is dissolved in the water phase contained in the formulation. Its negatively charged attracts it to the cationic micellar environmental where it will react with the negatively charged oxidant. This mechanism is termed "inverse phase-transfer catalysis".

In the formula, a set of decontamination formulation was developed for each of the reaction mechanisms described. A review of the fundamental chemistry of the TICs reveals that the majority of them can be neutralized by the formula reaction mechanisms. For example, most of the 21 TICs on the DOJ (The USA Department of Justice) high threat level list.

In general, there are only two classes of TICs for which the mechanism of decontamination could generate unexpected reactions:

1) Strong acids and bases, which are best neutralized by non-aqueous technologies to avoid violent reactions which may occur when water is added to strong acids or bases;

2) TICs that contain toxic metals, which by definition, cannot be chemically neutralized.

The reactions involved in decontaminating **chemical warfare agents**, particularly nerve agents (such as G agents or V agents) and blistering agents (such as mustard), can be divided into substitution and oxidation reactions. The chemical agents such as sarin, soman and tabun (G-agents) are all examples of phosphorus-containing compounds which, when altered chemically in substitution reaction like hydrolysis, can lose their toxicity. Mustard, which is an example of H-agents, and VX, which is an example of V-agents, can also be altered chemically and rendered harmless with oxidation reaction. The formula provides both solubilizing compounds: oxidizing and nucleophilic.

BWA

The formula is a bio-decontamination formulation that neutralizes biological pathogens for disinfection and sterilization applications. For neutralization of biological toxants the synergistic effect between the cationic surfactants and the hydrogen peroxide is responsible for the high rate of bio-agents kill: the solubilizing compounds (cationic surfactant) serves to solubilize and soften the biological agent's outer coat, thereby exposing the biological agent's DNA and vital parts to reactive compounds. After the solubilizing compound enhances exposure of the toxant to the reactive compound, the reactive compound reacts with the toxant, either by oxidation or hydrolysis reaction, to neutralize it.

Bacterial spore formers, like *Bacillus anthracis*, are considered as one of the most resistant organisms, with the lowest sensibility to disinfectants. The spores of these bacteria resist to heat, drying, and tomany disinfectants (including 95% ethanol). They are considered the most difficult bio-agent to kill. Because of these attributes, *B. anthracis* spores are extraordinarily well suited to be used as biological weapons.

When using The formulation for spore neutralization, the cationic surfactants soften and disrupt the spore coat resulting in breeches through which hydrogen peroxide can enter and attack the spore DNA. Test results against **anthrax spores** showed a **7-log reduction** (99,99999%) in 15 minutes.

For information, it is considered that standard autoclave equipment is effective in the treatment of biohazard material when it reaches log-4 (minimum). Spores such as *Geobacillusstearothermophilus* are used as indicator.

EPA (US Environmental Protection Agency) registered DF as Antibacterial, Cleaner, Mildewstat, Decontaminant, Disinfectant, Deodorizer, Fungicide, Algaecide, and Virucide.

Virucidal activity. The formulation disinfection mechanism against viruses is a result of the dual synergy between the surfactant oxidizing properties. In addition to these chemistries, peracetate is also produced and further acts as a strong oxidizer. Rapid degradation of capsid proteins and viral RNA has been observed in a relatively short contact time.

The formulation mechanisms of action on viral systems include a primary effect on the lipid envelope with subsequent degradation of viral capsid proteins, protein denaturation and dissociation of enzymes and interaction with lipids. These mechanisms impact on both enveloped and non-enveloped viruses. Surfactant or quaternary ammonium compounds (QAC) present in the formulation are compounds comprised of hydrophilic and lipophilic portion.

Hydrogen peroxide in the formulation generates free hydroxyl radicals that can break DNA and RNA structures, attack membrane lipids, and produce disruption in virus capsid structure and other essential cellular components.

The formulation demonstrated complete inactivation of Influenza A, Influenza B and Norovirus following a 10-minute exposure time. Bovine Coronavirus (BVC) viral agents were completely inactivated in less than 3 minutes.

Antibacterial activity. The formulation disinfection mechanism against bacteria is similar to virucidal disinfection. Surfactant physically denatures (via boring holes) bacterial protein armor. Oxidizing agents attack genetic material (DNA) and Hydrolyzing agents attack vital bacteria contents and functions.

Disinfection of a large number of different bacteria (gram + and gram -) has been achieved within a 10-minute contact time.

Mold remediation and antitoxin activity. The formulation dual synergy between the surfactant oxidizing properties has been demonstrated to be fungicidal and fungistatic. It is used to control mold. The formulation has been tested to neutralize mold, mold spores and mycotoxins produced by this organism (a toxic secondary metabolite produced by molds). One mold species may produce many different mycotoxins, and the same mycotoxin may be produced by several species.

Although the formula was developed primarily to neutralize chemical and biological warfare agents, and toxic industrial chemicals, it can also be used for the disinfection and sterilization of other biological pathogens that are related to public health issues.

Several TICs, biological and chemical warfare agents have been selected to test the formula decontamination effectiveness (see annex list of documented agents).

The formula has been demonstrated to provide disinfection efficacy on several surfaces (porous and non-porous): galvanized steel, butyl rubber, polypropylene, concrete, acoustic ceiling tile, commercial carpet, fabric-covered office partition panels, smooth latex, painted wallboard, painted metal, glass, sand, …

By the formulation specific chemical design and the way it treats bio and chemical agents (with all neutralization mechanisms already described) we can consider that no biological or chemical agent (including TICs) remains in their original state after being in contact with the formulation.

Radiological and Nuclear particles decontamination.

In addition to the formulation ingredients: quaternary amines and hydrogen peroxide; the formulation also contains a water-solution cationic polymer to increase the bulk viscosity of the solution, and fatty alcohols to increase the surface viscosity of the formulation. The formulation can be produced as "sticky foam", where glue-like additives have been used to increase the adhesive power to the foam. The fact that the formulation contains surfactants means that it has enhanced capability to penetrate porous objects, due to the effect of surfactant on reducing surface tension, increasing penetration power.

Based on its behavior and from the tests performed by ITEL (certificate #3700), we can consider this product effective in the disintegration of dirt. The formulation has a high capability to remove solid particles of different surfaces, ionizing radiological particles included, with a high effectiveness when applied accordingly.

Tests conducted by the Technical Unit of Radiation Protection (UAB –Autonomous University of Barcelona), showed the formulation's high decontamination efficacy against radiological particles on different surfaces.

Organism Type	
Bacteria	
Agrobacterium tumegaciens	*Neisseria catarrhalis*
Bacillus anthracis - (Anthrax)	*Phytomonastumefaciens*
Bacillusanthracis AMES-RIID	*Proteusmirabilis*
Bacillusanthracis ANR-1	*Proteusvulgaris*
Bacillus anthracis spores - (Anthrax spores)	*Pseudomonasaeruginosa*
Bacillusglobigii	*Pseudomonasfluorescens*
Bacillusmegateriumsp. (veeg.)	*Salmonella choleraesuis*
Bacillusparatyphusus	*Salmonella enteritidis*
Bacillussubtilis	*Salmonella paratyphi (Entericfever)*
Bacillussubtilisspores	*Salmonella spp*
Clostridiumdifficile	*Salmonella typhimurium*
Clostridiumtetani	*Salmonella typhosa (Typhoidfever)*
Corynebacteriumdiphtheriae (Diphteria's)	*Sarcina lutea*
Eberteliatyphosa	*Serratiamarcescens*
Enterobacteraerogenes	*Shigelladyseteriae (Dysentery)*
Enterococcusfaecalis	*Shigellaflexneri*
Erwiniaherbicola	*Shigellaparadysenteriae*
EscherichiaColi (0157-H7 & ESBL)	*Spirillumrubrum*
Escherichiacoli (E. Coli)	*Staphylococcusaerius*
Staphylococcushemolyticus	*Staphylococcusaeureus - MRSA*
Klebsrellapneumoniae	*Staphylococcusaeureus - VISA*
Legionellabosemanil	*Staphylococcusalbus*
LegionellaDumoffii	*Staphylococcusepidermidis*
Legionellagormanii	*Staphylococcushemolyticus*
Legionellalongbeachae	*Staphylococcuslactis*
Legionellamicdadei	*Staphylococcusspp*
Legionellapneumophila (LegionnairesDis.)	*Staphylococcusviridans*
Leptospiracanicola (infectionsJaundice)	*Straphylococcusaureus*
Listeria monocytogenes	*T4 Bacteriophage virus*
Micrococcuscandidus	*Vibrio comma (Cholera)*
Micrococcussphaeroides	*Xanthomonasaxonopodis (Citrus Canker)*
Mycobacterium tuberculosis (Tuberculosis)	*YesinaPestis*
Mold / Moldspores / Mycotoxins	
Aflotoxin: B1,B2, G1 and G2 (mycotoxin)	*Penicilliumdigitatum*
Altemia (moldspore)	*Penicilliumexpansum (olive)*
Arnerospores (moldspore)	*Penicilliumroqueforti (green)*
Ascospores (moldspore)	*Penicilliumvariabile*
Aspergilliusglaucus	*Penicillium/Aspergillus mold spore types*
Aspergilliusniger	*Periconia (moldspore)*
Basidiospores (moldspore)	*Roridin A (mycotoxin)*
Candidabombicola	*Smuts (moldspore)*
Chaetomium (moldspore)	*Stachybotryspores*
Citrinin. Penicilliumcitrinum (mycotoxin)	*Stachybotryschartarum*
Cladosporium (moldspore)	*Stachybotrysmoldspores*
Deoxynivalenol: DON orVomitoxin (mycotoxin)	*Stachybotrystoxins (mycotoxins)*
Mucorracemosus A	*Trichophytonmentagrophytes*
Mucorracemosus B	*Verrucarin A (mycotoxin)*
Myxomycetes (moldspore)	*Verrucarol (mycotoxin)*
Oosporalactis	
Virus	
Bcteriopface - E.Coli	*Influenza A*
BovineCoranovirus (BCV)	*Influenza B*
Bovine enterovirus (BEV)	*Inluenza A (H1N1 + H5N1)*
Ebola	*MS-2 Bacteriophage virus*
FelineCalicivirus (Norovirus)	*Poliovirus - Poliomyelitis*
Foot and Mouth Disease virus (FMDV)	*SARS Coronaviruses*

Infectious Hepatitis	*T4 Bacteriophage virus*
Algae	
Oocystissp	*Phormidiuminundatum*
Phormidiumfoveolarum	*Saxitoxin (algaetoxin)*
Yeast	
Brewersyeast	*Saccharomycescerevisiae*
Commonyeast cake	*Saccharomycesellipsoideus*
Saaccharomycesspores	
Protozoa	
ChlorellaVulgaris	*Paramecium*
NematodeEggs	
Arthropods	
Cimexlectularius	

ChemicalType	
1,1,3,3,3,-pentafluoro-2-(trifluoromethyl)-1-propene	*Iodine*
1,2-bis(2-chloroethylthio) ethane	*IsopropylAcetate*
1,3-bis(2-chloroethylthio)-n-propane	*Isopropyl Alcohol*
1,4-bis(2-chloroethylthio)-n-butane	*Ketones*
1,5-bis(2-chloroethylthio)-n-pentane	*Lactie*
2-chloroethyl phenylsulfide	*Likewise*
2-chloroethylchloromethylsulfide	*Malathion (liquid)*
2-chloroethylsulfide	*Menthamphetamine*
2-chlorovinyldichloroarsine	*Mercaptans*
3-quinuclidinyl benzilate	*Methanol*
Acetaldehyde	*MethylAcetate*
AceticAcid	*Methyl Alcohol*
Acetone	*MethylBromide (gas)*
Acetonitrile	*MethylChloride*
Alcohol's	*MethylEthylKetone*
Alkalinity	*methylphosphonyldichloride*
Alkylphosphites	*Mud and Sediment*
Alkylphosphonites	*Naphtha*
Alkylphosphonyidifluoride	*NitricAcid*
Alkylatedsalts	*Nitrobentene*
Amines	*Nitrotuluene*
Amiton	*O-alkyl*
AmylAcetate	*O-alkylphophoramidocyanidates*
Amyl Alcohol	*O-alkylphosphonofluoridates*
AnhydrousAmmonia	*Odors, General*
Antifreeze	*O-ethyl N, N-dimethylphosphoramidocyanidate (TABUN_GA Agent)*
Arsenictrichloride	*O-ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate (VX)*
Arsine (gas)	*O-ethyl S-ethyl (diethyl) phenyl phosphonothioate (malathion)*
Benzene	*Oil, Suspended*
bis(2-chloroethyl) ethylamine	*Oils, Dissolved*
bis(2-chloroethyl) methylamine	*O-isopropylmethylphosphonofluoridate (SARIN_GB Agent)*
bis(2-chloroethyl) sulfide (MUSTARD_HD Agent)	*O-pinacolymethylphosphonofluoridate (SOMAN_GD Agent)*

bis(2-chloroethylthio) methane	*OrganicAcids*
bis(2-chloroethylthioethyl) ether	*OrganicEsters*
bis(2-chloroethylthiomethyl) ether	*OrganicSalts*
bis(2-chlorovinyl) chloroarsine	*OxalicAcids*
Bleach (sodiumhypoclorite)	*Oxone*
BoronTrichloride (liquid)	*Oxyden*
ButilAcetate	*PCB's*
Butyl Alcohol	*Pesticides*
ButylIsocyanate	*Phenol*
CalciumHypachlorite	*Phosgene*
Capsaicin (Pepper Spray)	*Phosphorousoxychloride*
CarbonDisulfide	*PhosphorousTrichloride (liquid)*
Chloral (thrichloroethanol)	*Phosphoruspentachloride*
Chloramine	*Pinacolylalcohols*
Chlorine	*Plastic Taste*
Chlorine (gas)	*PlatingWaste*
Chlorobenze	*PotassiumPermanganate*
Chloroform (trichloromethane)	*PrecipitatedIron*
Chloropicrin	*PrecipitatedSulfur*
Chlorosarin	*ProploicAcid*
Cholophenol	*Proplonaldehyde*
Chorophyll	*PropylAcetate*
CitricAcid	*Propyl Alcohol*
Cresol (hydroxytoluene)	*PropylChloride*
Cyanogenchloride	*Protonatedsalts*
Defoliants	*Quinuclidin-3-ol*
Detergents	*Radon*
Dialkyl aminoethan-2-ols	*Ricin*
Dialkyl aminoethane-2-thiols,	*RubberHose Taste*
Dialkyl aminoethyl-2-chlorides	*s-2-dialkyl aminoethylalkylphosphonothiolates*
Dialkylphosphoramidates	*Saxitoxin*
Dialkylphosphoramidicdihalides	*Soap*
Diesel Fuel and Gasoline	*SodiumCyanide*
Dimethylmethylphosphonate	*SodiumHypochlotite*
Diphenylhydroxyaceticacid	*Soluble IronSolvents*
Diphenylchlorophosphate	*Sulfurdichloride*
Dyes	*SulfurDioxide (gas)*
Emulsions	*Sulfurmonochloride*
EthelEither	*SulphonatedOils*
EthylAcetate	*Suspended Matter*
EthylAcryiate	*Tannins*
Ethyl Alcohol	*TarEmulsion*
Ethyl Alcohol	*TartaricAcid*
Ethyl Amina	*Taste, DI Water and Organics*
EthylChloride	*Taxol (Paclitaxel)*
Ethylene Oxide (gas)	*TetraethylPyrophosphate (liquid)*

Fluorine (gas)	*Thiodiglycols*
Formaldehyde (liquid and gas)	*Thionylchloride*
Glycol's	*THM's (Trihalomethanes)*
Herbicides	*Toludine*
Hydrogen	*Toluene*
HydrogenBromide	*Trichloroethylene*
hydrogencyanide	*Tris(2-chlorovinyl) arsine*
HydrogenIodide	*TungstenHexaflouride (gas)*
HydrogenPeroxide	*Turpentine*
HydrogenSelenide	*Urine and Feces*
HydrogenSulfide (gas)	*Vinegar*
HypochorousAcid	*VolatineOrganicCompounds (VOC's)*
Insecticides	*Xylene*