HYGIENIZATION VIA PHOTOCATALYSIS AND NANOSILVER

Applications protocol
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Introduction

The applications of the photocatalytic process are highly recognized as a viable solution to environmental problems. The disinfection of bacteria is particularly important because traditional methods such as intensive chemical products have several drawbacks associated. The chlorine used for disinfecting can react with organic materials to create organochlorine compounds which are highly carcinogenic.

Hygiene is a simple, safe and economical solution for any environment constantly sanitize without using chemicals through photocatalysis. The semiconductor TiO$_2$ conveniently uses photocatalytic process that is nontoxic, chemically stable at a reasonable cost and susceptible to repeated use without substantial loss of catalytic ability.

Antibacterial mechanism of photocatalytic TiO$_2$ is assigned to the combination of damage to the cell and subsequent oxidative attack by cellular components internal membrane, resulting in cell death.

Photocatalysis

Photocatalysis is a phenomenon whereby a compound suffering the effect of light, speeds up a chemical reaction without being consumed. For this to happen, the compound needs to be excited with photon energy. A catalyst does not change in itself and isn’t consumed in a chemical reaction.

This definition includes photosensitization, a process in which a photochemical change occurs in a molecular entity as a result of the initial absorption of radiation by another molecular entity called the photosensitized. The chlorophyll of plants is a type of photocatalysis. Chlorophyll in photosynthesis captures sunlight to transform water and carbon dioxide into oxygen and glucose. The photocatalysis creates a strong oxidizing agent for decomposition of any organic matter to carbon dioxide and water in the presence of the photocatalyst, light and water.

Photocatalysis compared to Photosynthesis
Titanium Dioxide (TiO₂)

One of the most efficient photocatalysts (and present in hygiene) is titanium dioxide (TiO₂), a semiconductor on which various works have been published. The commercialization of products based on photocatalytic titanium dioxide began in the mid-90s in Japan. However, this industry has grown rapidly and its market share reached 30 billion yen in 2003. Its applications are mainly linings, road construction, air purification plants and other materials. Although they can be consider quite different products, all share the same ability to decompose harmful substances in the air and come into contact with the photocatalytic surface.

Titanium dioxide exists mainly in the crystallographic form of anatase and rutile. Rutile is widely used for pigment applications (e.g. paints), due to its high refractive index, giving it a white color. The anatase is a useful material for photocatalytic applications due to its strong oxidizing power when exposed to ultraviolet radiation, such as its chemical stability and absence of toxicity.

The spectral absorbance of light of the titanium dioxide lies in the ultraviolet radiation decomposes into three types: UV-A, UV-B and UV-C. Therefore, for photocatalysis occurs, a source of ultraviolet radiation is necessary. While in the exterior finishes such radiation can be provided by sunlight, inside the buildings, the fluorescent lights provide a smaller percentage of ultraviolet radiation.

Nanometric TiO₂ in the form of antase
Mechanism

When the photocatalyst of titanium dioxide (TiO₂) absorbs light from the sun or a light source lit (fluorescent lamps), it produces pairs of electrons and holes.
Inactivation of microorganisms by Photocatalysis
Effects

Antibacterial effect

Photocatalyst not only kills bacteria cells, but also decomposes the cell itself. It has been found that the photocatalyst titanium dioxide is more effective than any other antibacterial agent, because the photocatalytic reaction works even when there are cells covering the surface and as while the bacteria are actively spreading. It is expected that the final toxin produced in the cell death is also decomposed by photocatalytic action. The titanium dioxide does not deteriorate and has a long-term antibacterial effect. In general, disinfection by titanium oxide is three times more powerful than chlorine and 1.5 times stronger than ozone.

Deodorizing effect

On the deodorizing application, the hydroxyl radicals accelerate the breakdown of any Volatile Organic Compounds or VOCs by destroying the molecular bonds. This will help combine the organic gases to form a single molecule that is not harmful to humans, improving the air cleaning efficiency. Some examples of odor molecules are: tobacco odor, formaldehyde, nitrogen dioxide, urine and fecal odor, gasoline, and many other hydrocarbon molecules in the atmosphere. Air purification with TiO$_2$ can prevent smoke, dust, pollen, bacteria, viruses and harmful gases as well as seize the free bacteria in the air by filtering percentage of 99.9%, with the help of the highly oxidizing effect of photocatalyst (TiO$_2$).

Air purifying effect

The photocatalytic reactivity of titanium oxides can be applied for the reduction or elimination of compounds in polluted air, such as NOx, cigarette smoke, as well volatile compounds arising from various construction materials. Furthermore, the high photocatalytic reactivity may be applied to protect the lamps and walls of houses encapsulation as well as to prevent the white tents become sooty and dark. Atmospheric constituents - such as chlorofluorocarbons (CFCs) and CFC substitutes, greenhouse gases, and nitrogenous and sulfurous compounds undergo photochemical reactions either directly or indirectly can be removed in the presence of sunlight.

Nanogold

It has been demonstrated that silver nanoparticles have antibacterial and antifungal effects. With the circulation of air, the coated surfaces are in contact with the silver ions that can resist any bacteria in the air, which in turn suppress bacteria's respiration, adversely affecting cellular metabolism of bacteria and inhibiting cell growth. The nanogold destroy more than 650 disease-causing organisms.
Actions

**Kills germs**

 nygiene not only kills germs, but also decomposes his cell itself along with any toxic products.
Germs cannot become immune to nygiene.

**Removes allergens and irritants**

 nygiene purifies the environment by destroying airborne allergens and irritants such as pollen, tobacco and pet dander.
The product eliminates the need for harmful chemical and UV light commonly used for hygienization.

**Destroys deadly pollutants**

 nygiene is a simple and effective way to destroy harmful chemical pollutants like formaldehyde, styrene and toluene.
Photocatalytic technology will oxidize noxious chemical contaminants into harmless water and carbon dioxide.

**Eliminates unpleasant odors safely**

 nygiene destroys odors safely instead of camouflaging them with harmful chemicals.
It is ideal for any space that has lingering odors.

Applications

**Health**

Areas with intensive medical use is required a constant and thorough disinfection of surfaces and materials to reduce the concentration of bacteria and preventing bacterial transmission.
Disinfection with UV light is usually unsatisfactory, and have been associated health risks.
nygiene is a simple, safe and economical alternative to the process of disinfection.
Healthcare Associated Infections (HCAIs)

Healthcare Associated Infections (HCAIs) are infections that occur in patients during the process of care at the hospital or health facility that were not present or incubated at admission. Includes not only infections acquired in hospitals, but also those that appear after patient discharge and infections that affect the health professionals.

Colonized or infected host
People who carry bacteria without evidence of infection (fever, increased white blood cells count) are colonizers. Infections commonly develop from bacteria colonizing patients. Bacteria that colonize patients can be transmitted from one patient to another by the hands of healthcare workers. On the other hand, patients are incubated with infectious agents are infected hosts.

HCAI appears to be a hidden cross-cutting problem that no institution or country can claim to have solved yet. The prevention of HCAI is complex and requires the use of standardized criteria, availability of diagnostic facilities and expertise for its implementation and interpretation of results. Prevention systems for HCAI exist in many developed countries, but are virtually nonexistent in most developing countries. Estimating the incidence of HAIs in the US was 4.5% in 2002, corresponding to 9.3 infections per 1000 patients/day and 1.7 million infected patients.

Surgical Site Infection (SSI) is the most researched type of infection and most frequent type of infection in developing countries, with incidence rates between 1.2 and 23.6% of surgical procedures and a prevalence of 11.8%. Moreover, SSI rates vary between 1.2% and 5.2% in developed countries. The risk of acquiring HCAI is significantly higher in Intensive Care Units (ICUs), with approximately 30% of patients affected by at least one episode of HCAI with substantial associate morbidity and mortality.

Pooled cumulative incidence density was 17.0 episodes per 1000 patient/day in adult patients at high risk in industrialized countries. Moreover, the incidence of infections acquired by the UCI adults in developing countries varied between 4.4 and 88.9% and a density amounted cumulative incidence of 42.7 episodes per 1000 patient/day. Among adult ICU patients in developed countries, the pooled cumulative incidence densities of Blood Stream Infections Associated with the Use of Catheter (CR-BSI), Urinary Tract Infections Associated with Catheter (CR-UTI) and Ventilator-Associated Pneumonia (VAP) were 3.5 per 1000 CL-days, 4.1 per 1000 urinary catheter-days, and 7.9 per 1000 ventilator days, respectively. In developing countries, the pooled cumulative incidence densities of CR-BSI, CR-UTI and VAP was 12.2 per 1000 CL-Days, 8.8 per 1000 urinary catheter-days and 23.9 per 1000 ventilator days, respectively.

Newborns are also a high-risk population in developing countries and rates of neonatal infection are three to 20 times higher than in industrialized countries. The impact of HCAI implies prolonged hospitalization, long term disability, increased resistance of microorganisms to antimicrobials, an increased financial burden on health systems, and higher prices for patients and their families, and excess mortality. In Europe, HAIs originate 16 million extra days of hospitalization, and 37 000 deaths attributable, and
contributes to an additional 110 000 every year. The annual financial losses are estimated at around €7 billion, including direct costs only. In the US, about 99 000 deaths were attributed to HAIs in 2002 and the annual economic impact was estimated at about 6.5 billion dollars in 2004. The information in developing countries is again very scanty and no data is available at national or regional levels. According to the report on infections associated with devices in 173 ICUs from 25 countries in Latin America, Asia, Africa and Europe, the excess mortality in adult patients was 18.5%, 23.6% and 28.3% for CR-UTI, and CR-BSI and PAV, respectively. A review of several studies showed that increase length of stay associated with HCAI varied between 5 and 29.5 days. Most HCAI become evident within 48 hours or more following admission (typical incubation period). Several studies have reported that Surgical Site Infections manifest post discharge.

**Instruments related to spread of HCAI**

Central Venous Catheter

Indwelling Urinary Catheter
All of these tubes and catheters are to be inserted into the patient’s body so any contamination from the surrounding environment can lead to severe sepsis and, in some cases, death.

It is very important to sterilize these instruments and maintain the sterile air.

Different ways by which disease spreads

**Frequency of contact with surfaces**

All surfaces in the healthcare environment have the potential to harbor pathogens microorganisms. The potential for exposure to pathogens is based on the frequency of contact with a contaminated surface and the type of activity involved. For example, a table of the conference room has less potential for exposure to pathogens than the doorknob of a client/patient/resident room. Surfaces with a high level of touch require a more frequent cleaning regimen.

Most of the environmental surfaces will be adequately cleaned with water and soap or a detergent/disinfectant, depending on the nature of the surface and the type and degree of contamination. The processes/products used for cleaning and disinfection of surfaces and medical equipment must be compatible with the surfaces/equipment.

1) **High-touch surfaces**

High-touch surfaces are those who have frequent contact with hands. Examples include doorknobs, elevator buttons, telephones, call bells, bedrails, light switches, computer keyboards, monitoring equipment, dialysis machines, wall areas around the toilet and edges of privacy curtains. The high-touch surfaces in care areas require cleaning and disinfecting more frequently than the minimum contact surfaces. Cleaning and disinfection are usually made at least once a day - and more often the risk of contamination of the environment is higher (for example, intensive care units).

2) **Low-touch surfaces**

Low-touch surfaces are those with minimal hand contact. Examples include floors, walls, ceilings, mirrors and railings. Low-touch surfaces require regular cleaning (but not necessarily daily) when soiling or spills occur and when a client/patient/resident is discharged from the healthcare setting. Many low-touch surfaces can be cleaned
periodically rather than daily (if they are clean when they are visibly soiled).

**Vulnerability of the Client/Patient/Resident populations**

Different populations of clients/patients/residents have different vulnerabilities based on their susceptibility to infection. In some populations, such as bone marrow transplant or burn patients, susceptibility to infection is very high and may be affected by the environment. Cleaning frequency should be higher in areas with vulnerable clients/patients/residents populations.

1) **More susceptible**
   
   These are clients/patients/residents more susceptible to infection due to their medical condition or lack of immunity. This category includes those who are immunocompromised. For example, cancer patients, those on chemotherapy and transplant units, neonates (levels 2 and 3 nurseries), those with severe burns, or require care in a burn unit and those undergoing invasive or operational procedures (for example, hemodialysis).

2) **Less susceptible**
   
   For the purpose of risk stratification for cleaning, all others are classified as less susceptible.

**Patient susceptibility is determined by:**

1) Age: children and older people have lower resistance to infections.

2) Immune Status: patients with chronic diseases such as cancer, leukemia, diabetes mellitus, renal failure or AIDS have increased susceptibility to infections.

3) Immunosuppressive drugs or radiation.

**Environmental factors:**

1) Healthcare settings are environments were both infected people and people with high risk of infection gather.

2) Conditions of overcrowding in the hospitals leads to frequent patient transfers between units.

3) The microbial flora may contaminate objects, devices and materials that will subsequently come into contact with body parts of patients susceptible.

**Transmission:**

1) **Endogenous infection:** When normal flora of patients changes to pathogenic bacteria due to the change of environment, skin damage or inappropriate use of antibiotics. About 50% of N.I. are caused this way.

2) **Endogenous cross-infection:** Mainly transmitted through hands of healthcare workers, patients and visitors.

3) **Exogenous environmental infections:** Several types of microorganisms survive well in the hospital (hospital flora):
   a) In water, damp areas and occasionally in sterile products or disinfectants e.g. pseudomonas, acinetobacter.
   b) On items such as linen, equipment and supplies.
   c) In food.
d) In fine dust and droplet nuclei: some procedures that save lives may increase risk of infection e.g. urinary catheters, I.V.L., inhalation therapy, surgery.
e) Inappropriate use of antibiotics.

Probability of contamination of items and surfaces in the Healthcare Environment:
The probability of a surface, piece of equipment or care area being contaminated is based on the activity in the area, the type of pathogen involved and the microbial load. Areas that are heavily soiled with blood or other body fluids will require more frequent cleaning and disinfection of the areas that are minimally dirty or not dirty (e.g., living rooms, offices).

1) Heavy contamination
   An area is considered to be highly contaminated if the surfaces and/or equipment are exposed to large amounts of blood or other body fluids (e.g., delivery room, autopsy room, cardiac catheterization lab, burn unit, hemodialysis unit, Emergency Department, bathroom if the client/patient/resident has diarrhea or is incontinent).

2) Moderate contamination
   An area is considered to be moderately contaminated if the surfaces and/or equipment are contaminated with blood or other body fluids as part of routine activity (e.g., patient/resident bath room if the patient/resident is not incontinent) and the contaminated material are contained or removed (for example wipes). All rooms of clients/patients/residents and bathrooms should be considered at least moderately contaminated.

3) Light contamination
   An area is considered slightly contaminated or uncontaminated if the surfaces are not exposed to blood, body fluids or other items that come into contact with blood or bodily fluids (e.g., living rooms, libraries, offices).

Finishes and surfaces in the healthcare setting in areas where care is delivered:
Healthcare facilities should have policies that include criteria to be used in the choice of furniture and equipment to areas where healthcare is provided to the clients/patients/residents. Must be in place a process of cleaning the health units, including:

1) Choice of finishes, furnishings and equipment that are washable.
2) Certification of compatibility of cleaning and disinfection agents of health units with items and surfaces that are clean.
3) Identification of damaged items that can no longer be cleaned. The cleanability is an important consideration in the choice of materials for health care environments. This applies to materials for floors, ceilings, walls, equipment and furniture. Materials and finishes should also be capable of being subjected to detergents, cleaners and disinfectants for hospital quality. It is important to involve the Infections Prevention and Control, Occupational Health and Safety and Environmental Services in decisions regarding furniture and finishing.
Surfaces in healthcare settings
Important features of the surfaces in healthcare facilities for the prevention and control of infections:

1) Ease of maintenance and repair:
   a) Ripped textiles allow the entry of micro-organisms and cannot be cleaned.
   b) Items that are scratched or chipped allow the accumulation of microorganisms and make your cleaning and disinfection more difficult.

2) Inability to support microbial growth:
   a) Materials that hold moisture are more likely to support microbial growth.
   b) Materials such as metal and hard plastics are less susceptible to support microbial growth.
   c) Wet organic substrates (e.g., wood) should be avoided into areas with immune-compromised patients.

3) Surface porosity:
   a) It is scientifically proven that the microorganisms survive in porous fabrics, such as cotton, terry cotton, nylon, polyester and plastics such as polyurethane and polypropylene.
   b) In patient-care areas where immunocompromised patients are located the use of upholstered furniture should be minimized.

4) Absence of seams:
The seams can hold bacteria and are difficult areas to clean. New products coated with materials that retard the growth of bacteria (e.g., stainless steel coated with titanium dioxide, coated glass xerogel) are being developed. Although anecdotal report has suggested that the antimicrobial impregnation of a carpet runner in a transplant unit may have retarded the growth of Aspergillus on the carpet, there is no evidence that the antimicrobial impregnation of items in the environment is associated with a reduced risk of infection or cross-transmission of microorganisms in health care. Products with "antibacterial" claims should be carefully evaluated before use.

Finishes in healthcare settings (Walls, floors)
All finishes (e.g., wall treatments, floor finishes) in healthcare areas must be chosen having the cleaning processes into account, especially where contamination with blood or body fluids is possible.
An assessment of risk prevention and control of infections by a multidisciplinary group (which includes an Infection Control Professional ICP) should be performed to ensure that all surfaces and finishes meet at least the preferred surface characteristics:

1) Ease of maintenance/repair and cleaning ability
2) Inability to support microbial growth
3) Smoothness (nonporous)
4) Good absorption/acoustics
5) Flammability (Class I fire rating)
6) Durability
7) Sustainability
8) The presence of low levels of volatile organic compounds (VOCs) to reduce outgassing
9) Low smoke toxicity
10) Initial cost-effectiveness and life cycle
11) Slip resistance
12) Ease of installation, demolition and replacement
13) Suitability
14) Resilience and impact resistance
15) Non-toxic and non-allergenic.

High-touch surfaces in Healthcare settings

Critical

Semicritical
Principles of cleaning and disinfection of Health Units

**Surfaces in the healthcare environment:**
The health facilities are complex environments that contain a large diversity of microbial flora. Many of these microbes may pose a risk to the clients/patients/residents, staff and visitors from space. The transmission of microorganisms within a healthcare environment is complex, very different from the transmission outside healthcare settings and the consequences of transmission may be more severe. The high-touch surfaces in healthcare facilities represent a greater risk than the public areas of the organizations that are non-health, due to the nature of the activity undertaken in the healthcare environment and the transient behavior of employees, patients and visitors under the health care setting.

**Transmission involves:**
1) The presence of an infectious agent (e.g., bacteria, viruses, fungi) in equipment, objects and surfaces in the healthcare environment.
2) A mechanism that allows the infectious agent to transfer from patient to patient, from patient to employee, employee to patient and/or employee to employee.
3) Presence of clients/patients/residents, staff and/or visitors susceptible. In the context of healthcare, the role of sanitation is important because it reduces the number and quantities of infectious agents which may be present and may also eliminate the pathways of microorganisms from a person/object to another, thus reducing the risk of infection.

**The environment of healthcare setting:**
The environment of healthcare settings has shown to be a reservoir of infectious agents such as bacteria (e.g., Staphylococcus aureus resistant to methicillin (MRSA), vancomycin-resistant enterococci (VRE), Clostridium difficile, Acinetobacter baumannii, Pseudomonas spp., Stenotrophonas ), viruses (e.g., influenza, respiratory sincial RSV virus, norovirus, astrovirus, sapovirus, rhinovirus -. flu) and fungi (e.g., Aspergillus spp, Fusarium spp, Penicillium spp, Stachybotrys spp).
Bacteria are the most common pathogens.

1) **Commensal bacteria**: found in the normal flora of healthy humans by preventing colonization, for example.

2) **Pathogenic bacteria**: have great virulence and infections such as:
   a) Anaerobic gram +ve rods e.g. Clostridium causing gangrenes.
   b) Gram +ve bacteria: Staphylococcus aureus found on skin & nose. - Beta -hemolytic Strep.
   c) Gram -ve bacteria as E. coli, Proteus, Klebsiella, legionella species.
   d) Viruses: HIV, HBV, HCV can be also be transmitted through blood & BF (transfusion, injections, dialysis), respiratory syncytial virus, ebola, influenza, herpes simplex viruses.
   Parasites & Fungi: e.g. Giardia lamblia is easily transmitted between adults or children, Aspergillus sp. affecting immunocompromised.
   e) Scabies an ectoparasite causing outbreak.

Percentage of environmental cultures positive for MRSA, by direct plating and by broth enrichment, by item cultured

![Chart showing percentage positive for MRSA](chart.png)

**Cleaning agents and disinfectants**

The key for cleaning is to use friction to remove the microorganisms and debris.

The cleaning is the removal of foreign material (e.g., dust, dirt, organic materials such as blood, secretions, excretions and microorganisms) from a surface or object. The cleaning physically removes instead of killing microorganisms, reducing the burden of organisms on a surface. It is
performed with water, detergents and mechanical action. The key for cleaning is to use friction to remove the microorganisms and debris. A thorough cleaning is required for any equipment/device to be disinfected because the organic material may inactivate a disinfectant. This can be achieved via a two-step process that involves a cleaning followed by a disinfectant, but in the area of healthcare is more common that it is carried through a one-step process using a cleaning/disinfector combined. Disinfection is a procedure used in inanimate objects and surfaces to kill microorganisms. Disinfection will kill most disease-causing microorganisms but may not kill all bacterial spores. Only sterilization will kill all forms of microbial life.

**Detergents and cleaning products**

Detergents remove suspended organic material and grease or oil. Equipment and surfaces in the healthcare environment should be cleaned with cleaners and disinfectants with approved hospital-grade cleaners and disinfectants. The cleaning/disinfection of equipment must be done as soon as possible after their use. There are various numbers of products and suppliers available in the market to achieve effective cleaning. It is important to follow the manufacturer’s instructions when using cleaning products.

**Disinfecting products used in the healthcare setting:**

1) Must be approved by Environmental Services, Infections Prevention and Control, Occupational Health and Safety.
2) Must be used according to the manufacturer’s recommendations for dilution, temperature, water hardness and usage.
3) It must be used in accordance with the product’s Material Safety Data Sheet.

**Disinfectants**

Disinfectants rapidly kill or inactivate most infectious agents. The disinfectant should only be used to disinfect and should not be used as cleaning agents in general, unless combined with a cleaning product as a disinfectant detergent.

1) **Choosing a disinfectant**

The following factors influence the choice of disinfectant:

a) The disinfectant must have a drug identification number (DIN)
b) The nature of the item being disinfected
c) The innate resistance of expected microorganisms to the inactivation effects of the disinfectant
d) The amount of organic soil present
e) The type and concentration of disinfectant used
f) Duration of contact time required for the efficacy at the usual room temperature of the healthcare facility
g) If you are using a particular product, other specific indications and directions for use
h) Occupational health considerations

i) Many surfaces disinfectants containing quaternary ammonium compounds (QUATs), phenolics, hydrogen peroxide or sodium
hypochochlorite which can cause skin and respiratory irritation
j) Disinfectants are one of the leading allergens affecting health care providers
k) Health professionals should use products that are non-toxic and non-irritating
l) Environmental Protection:
m) Consider products that are biodegradable and safe for the environment
n) Many disinfectants (e.g., QUATs) may be dangerous either during the process of production or when they are discharged into the waste stream since they are not readily biodegradable.

2) Using disinfectants
When using a disinfectant:
a) It is very important that the item or surface is free of dirt and other agents that may interfere with the action of the disinfectant - for example, adhesives must be removed before you apply a disinfectant or the sanitizer will not work. Most disinfectants rapidly loses its effectiveness in the presence of organic matter.
b) A hospital-grade disinfectant can be used for equipment that only touch intact skin - examples include intravenous pumps and stanchions, hydraulic lifts, blood pressure monitors, apnea monitors and sensors, ECG machines (ECG)/wires and crutches.
c) It is important that the disinfectant be used according to the manufacturer's instructions for dilution, and contact time.
d) It should minimize the contamination levels of disinfectant solution and the equipment used for cleaning: this can be achieved by ensuring adequate dilution of the disinfectant, often changing the disinfectant solution and not dipping a dirty cloth in disinfectant solution (no "double-dipping");
e) Appropriate personal protective equipment must be worn for the product(s) use(s).
f) There should be a system of quality monitoring to ensure the effectiveness of the disinfectant over time (e.g., conducting frequent tests the product).

New and involving technologies

Before considering a change from current methods for cleaning and disinfection in the healthcare setting, the newer product must be weighed against current product in terms of efficacy, ease of implementation, toxicity, effects on patient care, and ergonomic aspects cost implications. Infections Prevention and Control, Environmental Services, Occupational Health and Safety must be involved in all decisions regarding changes to products and methods for cleaning and disinfection in the health unit.

1) Air disinfection/fogging
The techniques of disinfectant spray have been used in some countries to finalize the cleanliness of the room, but are not frequently used. Toxic gases such as formaldehyde and ethylene oxide have been used in the
past but are not currently recommended due to security risks and long cycle times. More recent gaseous formulations such as vaporized hydrogen peroxide (VHP), super-oxidized water and ozone gas, have been shown to be effective in comparison with the standard environmental cleaning microorganisms such as C difficile and MRSA. The disinfectant spray techniques are not suitable for routine cleaning and must be restricted to the terminal cleaning of isolation units and rooms involved in uncontrolled outbreaks.

2) Vaporized Hydrogen Peroxide (VHP)
Vaporized Hydrogen Peroxide is effective against a wide range of microorganisms including bacteria, viruses and spores and particularly those of C. difficile. It has been used successfully in the eradication of Serratia marcescens neonatal intensive care units and MRSA, VRE and C difficile surgical units. VHP is relatively safe and decomposes into water and oxygen. The steam is normally supplied by a distribution system controlled by the computer which ensures a uniform distribution throughout the room while monitoring the gas concentration, temperature and relative humidity. When decontamination is complete, a ventilating unit in the room VHP converts into water and oxygen. The decontamination process takes around five hours. The Vaporized Hydrogen Peroxide system has been successfully used in France achieving decrease C. difficile infection of 91%, compared to a 50% reduction using sodium hypochlorite. Before disinfection cleaning of the environment was performed with detergent. The time required for decontamination haze is about 1.5 hours (depending on the room volume).

In a study by French et al, contaminated with MRSA isolated rooms were decontaminated with VHP more effectively than routine cleaning measures. Steam was particularly effective for the decontamination of complex equipment and furniture that is difficult to clean manually. Daily use of VHP is not advised. This should be used during outbreaks, when other control measures have failed and when the environment implicated in the transmission may be at risk.

Advantages and disadvantages of Vaporized Hydrogen Peroxide

Advantages:
- More effective decontamination compared to routine cleaning
- Less labor required
- By-products are safe for the environment
- Useful for decontaminating soft furnishings and equipment that is difficult to clean
- May be used to decontaminate entire units/wards during outbreaks

Disadvantages:
- Time-consuming (average of five hours to complete VHP)
- Biological soil reduces the efficiency of VHP
- Air conducts from the room must be sealed prior to decontamination and the ideal methodology (including exposure time) are still under investigation
- Expensive
3) **Ozone gas**

Ozone is a gas that has bactericidal properties, can be generated inexpensively and quickly dissociates oxygen. Ozone gas is widely used in water disinfection to control Legionellae and has been successfully to inactivate feline calicivirus (a surrogate for Norovirus) in small rooms such as hotel rooms and cruise cabins, and to eliminate MRSA from home a healthcare provider with eczema. Recent studies show the use of ozone gas as a promising antibacterial agent in health care environments. However, in high concentrations, is toxic, which prevents their use in populated areas. Should be used only in areas that can be completely isolated during the treatment period.

**Advantages and disadvantages of Ozone gas**

**Advantages:**

- a) effectively penetrates in all areas of a room, even areas difficult to access or clean by conventional cleaning methods (ex.: tissues, under beds, inside cracks)
- b) Administration of gas can be controlled from outside the room
- c) Easy and economical to produce
- d) By-products are safe for the environment
- e) Decontaminates surfaces, even if biological materials have been dried onto them
- f) Decontaminates a large area quickly (less than one hour for an entire room)

**Disadvantages:**

- a) Toxic in high concentrations
- b) Area to be decontaminated must be isolated until ozone levels return to safe limits

4) **Super-Oxidized water**

Super-Oxidized Water has hypochlorous acid as the main ingredient. The hypochlorous acid is safe to use, is not harmful to the environment and has a broad spectrum of activity that includes spores. Many formulations have a long shelf life and are safe for the environment. The use of super-oxidized water as a disinfectant vaporous is promising, but requires further investigation before its application in health care units.

5) **Ultraviolet irradiation (UVI)**

The use of ultraviolet irradiation (UVI) in the healthcare setting is limited to the destruction of airborne organisms or inactivation of microorganisms on surfaces. UVI inactivates microorganisms at wavelengths of ultraviolet light 240 to 280nm. Bacteria and viruses are more easily dissolved by UVI than bacterial spores.

Germicidal effectiveness of UVI is influenced by:

- a) amount and type of organic matter present
- b) the wavelength of ultraviolet light
- c) air mixing and air velocity
- d) temperature and relative humidity
- e) type of microorganisms present
- f) the intensity of ultraviolet light, which is affected by distance and light pipe cleaning
If UVI is used in a healthcare environment, warning signs should be placed on the affected area to warn employees, clients/patients/residents and visitors of the danger. A schedule for replacing ultraviolet lamps according to the manufacturer's recommendations should be developed. The intensity of UVI should be monitored regularly.

**UVI disinfection of the air**

Several studies have shown that UVI is effective in killing or inactivation of M. tuberculosis and limiting the transmission of other infectious agents in hospitals. In the US, the UVI is recommended as a supplement or complement to other measures to TB infection control and ventilation measures in settings in which the need to kill or inactivate M. tuberculosis is essential, such as airborne infection isolation room in. UVI is not a substitute for HEPA filtration in airborne infections isolation rooms.

**UVI disinfection of surfaces**

UVI disinfection has been used successfully for final disinfection of isolation units once patients have been treated for infections. Cleaning of visibly soiled surfaces is necessary before UVI because ultraviolet light is absorbed by organic material and its ability to penetrate is reduced. The disinfection of surfaces by UVI should not be used alone for disinfection, but may be a good compliment to chemical disinfection to reduce the microbial load in isolation units and during outbreaks.

**Advantages and disadvantages of UVI disinfection of surfaces**

**Advantages:**

- a) Automated method - no manual labor is necessary
- b) Relatively short exposure time required (40 minutes)
- c) Leaves no residue after disinfection

**Disadvantages:**

- a) Destructive effect over time on plastics and vinyl's and fading of paints and fabrics
- b) Low penetrating effect
- c) Less effective in the presence of organic materials
- d) Disinfection does not occur in shadowed areas, where UV light cannot penetrate
- e) Expensive
- f) Rooms must be empty during the UVI disinfection and a warning sign should be placed
- g) Staff should avoid entry during the process of disinfection UVI

6) **Steam vapor**

Steam has been used effectively to sterilizing medical equipment, but has not been used for disinfection of surfaces, due to the size and the immobility of the equipment used to provide the steam. Recent advances in technology have drastically reduced the size of the steam generators, making them portable and practical. Saturated steam is composed mostly of water in the vapor phase and is warmer and drier than the typical vapor, which is often laden with tiny droplets of liquid water. Because sutured steam is drier than the typical vapor, it poses no extra risk to electronic devices and other devices than regular liquid.
disinfectants. Care should be used around in thin plastic films to avoid distortion of steam heat.
Portable steam generators can be used to clean kitchens, bathrooms, floors, walls and other surfaces using a brush nozzle through which the steam comes out. The vapor is applied using a reciprocating motion for five to ten seconds. Grease, oil, stains and dirt are effectively extracted and microorganisms are extinct. The steam vapour efficiently travels through biofilm to kill microorganisms that may be inaccessible by surface application of disinfectants. Portable steam vacuums have demonstrated to be effective against bactericidal activity, virucidal, fungicidal against C. difficile spores in experimental situations. Further study in clinical situations is needed.
Ideally, the patient/resident should be out of the room during high scan - consist of all surfaces and equipment above shoulder height, including ventilation - to reduce the risk of inhalation of spores from dust particles.
To perform high scan:
1) Use HEPA-filtered vacuums or chemically treated damp mops/cloths.
2) Proceed either clockwise or counter clockwise from the starting point to avoid missing any surface.
3) Observe and report stained or misplaced ceiling tiles, fixtures or walls destroyed so they can be replaced or repaired.

Scheduled cleaning in operating room suites (sample)

<table>
<thead>
<tr>
<th>Sr. N.o</th>
<th>Areas</th>
<th>Schedule</th>
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<tbody>
<tr>
<td>1</td>
<td>Ceilings, including air conditioning, ventilation grills/vents and light fixtures</td>
<td>Twice yearly</td>
</tr>
<tr>
<td>2</td>
<td>Walls, all doors and windows</td>
<td>Monthly</td>
</tr>
<tr>
<td>3</td>
<td>Floors, including baseboards, corners and edges</td>
<td>Monthly</td>
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<tr>
<td>4</td>
<td>Store rooms and storage areas</td>
<td>Monthly</td>
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<tr>
<td>5</td>
<td>Exterior surfaces of machines and equipment</td>
<td>Monthly</td>
</tr>
<tr>
<td>6</td>
<td>Refrigerators and ice machines</td>
<td>Monthly</td>
</tr>
<tr>
<td>7</td>
<td>Furniture, including wheels/casters</td>
<td>Weekly</td>
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<tr>
<td>8</td>
<td>Sterilizers, cabinets and doors (all shelving, computers, keyboards, etc.)</td>
<td>Weekly</td>
</tr>
<tr>
<td>9</td>
<td>Offices, lounges and locker rooms</td>
<td>Daily</td>
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</table>
Hemodialysis centers are highly contaminated areas

The patient’s hemodialysis station is comprised of the bed, dialysis chair, and table and dialysis machine components. Any item taken into a hemodialysis station could become contaminated with blood and other body fluids, therefore serve as a vehicle of transmission to other patients, either directly or through contamination via the hands of staff. Each dialysis station should be treated as an individual entity: cleaning must be done at the entry of the station and the exit of the station, before doing other tasks with the unit. The items brought to the patient’s hemodialysis station, including those that are placed on top of dialysis machine, should be disposable, or cleaned and disinfected before being returned to the common area and be used for other patients. Items that cannot be adequately cleaned and disinfected should not be taken to a hemodialysis station. Medicines or materials brought into the station should not be returned to common area or used on other patients.

The external surfaces of the hemodialysis machine and its components are the most likely sources of contamination by blood borne viruses and pathogenic bacteria. This includes surfaces frequently touched, such as the control panel, but also waste containers, pipes and blood items placed on top of the machines (e.g., file). The waste generated by contaminated blood dialysis station should be treated as biomedical waste. All disposable items should be placed in bags thick enough to prevent leakage.

Contact precautions - Norovirus

Noroviruses are a group of non-enveloped viruses that cause acute gastroenteritis in humans. Noroviruses are highly contagious and are transmitted in healthcare through direct person-to-person contact, by hand transfer of the virus after touching contaminated materials and environments surfaces, or via droplets of vomitus. Norovirus outbreaks in hospitals and nursing homes may be extended due to the high potential level of environmental contamination and the regular introduction of susceptible individuals. Noroviruses can survive in the environment for at least 12 days. Products used for the disinfection of norovirus should have an appropriate virucidal claim. Most QUATs has no significant activity against noroviruses. In some jurisdictions, it is recommended hypochlorite at 1000 ppm. Norovirus is inactivated by temperatures above 60ºC. The vacuuming of carpets and polishing floors during an outbreak has the potential to re-circulate norovirus and are not recommended. Cleaning regimes for norovirus should include:

1) Immediate cleaning of vomit and feces and nearby items, followed by disinfection with an appropriate virucidal disinfectant
2) Increased frequency of bathrooms cleaning and disinfection on affected units.
3) Replacement of privacy curtains on terminal cleaning.
4) Steam cleaning of carpets and furniture following regular cleaning - provided they are heat tolerant, and that the unit reaches at least 60 °C
5) Restrict adherence to hand washing.

**Resistance of microbes to disinfectants:**
Disinfecting the surfaces by itself is not sufficient for complete cleaning in hospitals.
Decreasing order of resistance of microorganisms to disinfectants/sterilants:

*Prions > Spores > Mycobacteria > Non-enveloped viruses > Fungi > Bacteria > Enveloped viruses*

The resistance of pathogenic organisms to the disinfection treatment can be attributed to the structural components in the outer layers of the microbial cell.
Traditionally, the microbial susceptibility to antiseptics and disinfectants has been classified based on these differences with decreasing order of resistance to antiseptics and disinfectants as follows:

*Coccidian cysts (Cryptosporidium) > Spores (Bacillus sp., C. difficile) > Gram-negative bacteria (Pseudomonas sp., E. coli) > Gram-positive bacteria (Staphylococcus)*

**Biofilm formation:**
The bodies of biofilm formation normally colonize the surfaces of implants and devices, resulting in the formation of complex "communities" and microbial resistance.
Contaminated devices and implants often require removal and replacement causing discomfort to the patient, increasing the demand for surgical services and causing an additional financial burden on the healthcare system.
Biofilms are composed of a matrix of extracellular polysaccharide protects the bacterial cell from host defense mechanisms and antimicrobial agents.

**Flaws in current practices and new methods of disinfection**

Even after applying a large amount of high-grade disinfectants and stringent application procedures, we are still facing problems related to Hospital Care Associated Infection. The reason behind this is that current practices are concentrated in "batch cleaning" - we are cleaning the surface at a given time and after a while develops a new bacterial load on this surface, we turn to clean it and the same cycle of bacterial development and cleanup continues. But what we need at this time is a "continuous process", which is able to sterilize surfaces, as well as prevent the development of new bacterial load.
New disinfection methods are being sought to provide additional means of protection in several areas where outbreaks of diseases can lead to illness or fatalities. For example, the risk of contamination arising from contact with surfaces and medical devices has received much attention due to the increased incidence of infections acquired in healthcare facilities. It is
possible that the reducing bio-burden on this sites may supplement the disinfection protocols currently in place and help reduce the risk of infection. Photocatalytic surfaces offer promise as innovative and cost-effective biocide engineering solutions, which address these specific issues, maintaining strict health and safety control.

A method was developed to evaluate the efficiency of the catalytic disinfection of surfaces allowing:

1) Determination of the pathogen viability as a function of treatment time;
2) Assessment of the surface for viable surface bond organisms after disinfection;
3) Measurement of the regrowth potential of inactivated organisms.

This method was used to demonstrate the inactivation of extended spectrum beta-lactamase of Escherichia coli, methicillin-resistant Staphylococcus aureus, Pseudomonas aeruginosa, and Clostridium difficile spores using immobilized films of commercial titania nanoparticles observed 99.9% reduction in viability of all bacterial cells after 80 minutes of photocatalytic treatment.

Complete surface inactivation was demonstrated and bacterial regrowth was not observed after the photocatalytic treatment. Greater than 99% inactivation was observed when the photocatalytic surfaces were challenged with Clostridium difficile.

The effectiveness of the photocatalytic disinfection to inactivate Staphylococcus epidermidis cells within a biofilm was also demonstrated, with 3 hours treatment to yield 96.5 ± 6% of the biofilm cells coating the TiO$_2$ substrate nonviable.
Food processing industry

Due to the antibacterial applications of TiO$_2$, this process is promising for the elimination of microorganisms in areas where the use of chemical cleaning agents biocides are ineffective or is limited by regulations - for example, in the food industry. TiO$_2$ is nontoxic and was approved by the American Food and Drug Administration for use in foods, medicines, cosmetics and materials in contact with food.

Packaging film coated with TiO$_2$ were effective in inactivating the E. coli in vitro when irradiated with UVA light. Tests on cut lettuce stored in bags coated with TiO$_2$ film under UV irradiation also demonstrated the efficacy of this method for the reduction of E. coli colonies, indicating that hygiene reduce microbial contamination on the surface of solid food products and consequently reduces the risk of microbial growth on food.

TiO$_2$ has shown to be effective in inactivating other foodborne bacteria such as salmonella cholereraesuis, vibrio parahaemolyticus and listeriamonocytogenes. The disinfection of surfaces is also of great importance to the food processing, since the food-borne infections can be caused by the proliferation and resistance to cleaning procedures of pathogens on the surfaces of production equipment in the food industry.

Studies involving E. coli strains synthesizing Curli, a type appendix which allows bacteria to adhere to surfaces and to form biofilms were able to inactivate this organism using titanium dioxide and various kinds of UV radiation. In the studies in the dark events, bacterial non-inactivation was recovered after 48 hours, indicating that the durability was adequate disinfection. Nitrogen-doping titania photocatalyst was also reported in a separate study using visible light to inactivate E. coli bacteria and biofilm. The disinfection of E. coli using TiO$_2$-containing paper and fluorescent UV irradiation has also been shown.

Construction

Air pollution in cities has increased in recent decades, with consequences in the quality of the urban environment, such as the cost of maintenance of the buildings, especially in their facades.

The coated external surfaces can stay clean only to the action of sunlight and rainwater due to photocatalytic and hydrophilic properties of titanium dioxide. It isn’t true that a surface coated with hygiene never get dirty, as the self-cleaning process depends on the lighting conditions, rainfall and accumulation of dirt, but it is a fact that hygiene will slow the rate of contamination of surfaces, saving considerable time and money on maintenance and cleaning operations that are normally difficult for very tall buildings and flexible plastics.

External surfaces

All external surfaces are candidates to possess photocatalytic properties, provided they receive sunlight - ultraviolet radiation source essential to catalyze chemical reactions through the titanium dioxide. The coating of surfaces improve their characteristics from external agents, such as air pollution, taking advantage of the sun’s action and rainfall.
With the titanium dioxide, the coated external surface becomes hydrophilic, attracting water droplets, which makes it forms a sheet of water on these surfaces by washing the products of chemical reactions. Rainwater does this role perfectly. The hydrophilic property can be especially important in optical terms, in vitreous surfaces, as prevents the formation of drops of water that contribute to the surface to fog.

**PVC**
The sun and rain can be devastating over time in a PVC surface. Titanium dioxide will retard the speed PVC contamination.

**Ceramic**
The runoff can cause stains that remove the aesthetic value to the facades. Whit a surface coated with titanium dioxide that is no longer a problem.

**Glass**
The buildings have windows, whose main function is to receive natural light. Using the glass becomes increasingly difficult to clean and keep clean. Glass is the material par excellence to perform this function due to its transparency and resistance. This takes up a significant area in front of most buildings, there still constructions whose facade is composed only of glass.

**Concrete**
The cement may contain in its composition a small proportion of titanium dioxide which leads to a mortar, or concrete having photocatalytic characteristics. One application of this technology was the construction of the church "Dives in Misericordia", in Rome. The white structures were built with white architectural concrete high-performance based on this new type of concrete with photocatalytic properties to maintain the aesthetic aspect of the assembly, also assured the strength of the structure.

**Steel**
It is also possible to be applied titanium dioxide film on steel. According to a test conducted on this substrate, the decomposition was observed stearic acid layers and coating efficiency as an antibacterial against Escherichia coli.

As can be seen, there is no external surface where this nanotechnology can not be applied. Since concrete paints and polymers, all have potential to become a photocatalytic surface. In the case of chemical incompatibility between the material and titanium dioxide (for example, a material which is capable of being decomposed by the photocatalytic reaction) can be applied between the two substrates to prevent their contact.

**Interior surfaces**

You can also apply the titanium dioxide on interior surfaces. The main obstacle is the lack of ultraviolet radiation in the vast majority of former environments. In fact, similarly to what occurs in the claddings, the catalyst
will perform its function since it is affected by the frequency of photons needed to trigger the photocatalytic reaction, which can be achieved with the installation of nygiene ultraviolet lamps.

**Retail**

Nygiene will help in product quality, increase shelf life of the product, avoid cross-contamination, allowing immediate corrective action and/or prevent recoveries. It is effective in removing organic pollutants: improves air quality, eliminates unpleasant odors and kills viruses and deadly bacteria, making the environment healthier.

Example sectors of this activity:

**Flower shop**

Greenhouses and warehouses have high levels of bacteria, mold and fungi. They’re a nightmare for any gardener, florist or importer of flowers. These microorganisms dramatically reduce the shelf life of cut flowers and creates a hazardous work environment. Nygiene offers a solution that removes 99.9% of viruses, bacteria, mold and fungi in seconds.

**Bakery**

Consumers and authorities are increasingly demanding with regard to food safety standards and care for the food during all phases of the process - from production to the arrival of the product to the consumer. As bread seller, the quality of your product and services are dependent on others, but hygiene is your responsibility. The application of nygiene meets current food safety requirements.

**Hotels and restaurants**

Nygiene will effectively reduce airborne microorganisms, volatile organic gases and other detectable human parameters - reduction of 99% of the microorganisms airborne and VOCs.

**Hotels**

Any catering business faces numerous challenges with regard to cleanliness and hygiene of the environment for its customers. Catering and public areas such as gyms, bathrooms and reception are just some of the risk areas. No matter how friendly and efficient the staff is, if the cleaning and hygiene of the hotel don’t meet the customer expectations, that is, be held to the highest hygiene standards, customers will not come back. Investing in hygiene care makes sense for the continuity of your business.
Restaurants

Food security requirements are increasing. Increasingly, it is necessary to comply with all rules about food and the hygiene careful in order to keep the business open. As a restaurant owner, the quality of your product may be dependent on others, but hygiene is your responsibility.

Home care

Hygiene is effective in removing organic pollutants: improves air quality, eliminates unpleasant odors and kills viruses and deadly bacteria, making the home a healthier living environment.

Bathroom

The cleanliness and hygienization concepts are commonly confused, however, cleaning only denotes the dirt abstention or dust on a surface, while hygienization is defined as something free of germs. However, while people take care of personal hygiene, environmental hygiene (hygiene related to the environment) is often forgotten. Washrooms are an accommodation that generate germs and microorganisms: the slots floor, behind the faucet within the toilet or near drain, the presence of these microbes is massive. If we add to these factors the odors emanating, not only from the drains but also the activities carried out there, the bathrooms become unbearable and unhealthy places to use. Observing this trend, several deodorants and technological accessories to combat microbial growth in toilets have appeared on the market. However, there are a number of challenges involved in the reorganization of toilets - many disinfectants or deodorants may involve the use of chemicals that can be unhealthy in the long term. Moreover, there are times in which the toilets deodorants have a mixture of odors which makes the odor becomes worse.

Air purification

Hygiene purifies the environment by destroying airborne allergies and irritants such as pollen, tobacco smoke and the animals. The pollution indoors is usually caused by volatile organic compounds and chemical contaminants dropped several products, applications and equipment; is a serious health problem and should be eliminated to provide a safe, healthy and productive. Air fresheners, scented gels, aerosols or electric air fresheners may also release chemicals such as benzene, formaldehyde and phthalates that are associated with respiratory problems and possibly the development of cancer. Hygiene also works to destroy these chemicals. The photocatalytic nano technology employs an oxidation with the device that transforms chemical contaminants into carbon dioxide and harmless.
Car

British scientists at the University of Birmingham conducted a survey which shows that the car seats for children have, on average, twice more germs than a public toilet.

20 samples were taken from child seats showing that an average of 100 potentially harmful bacteria and fungi in each square inch of the object. Salmonella - feature disease by high fever, abdominal cramps and diarrhea - and E. coli - responsible for acute burning during urination -, are some of the bacteria that a user can get from contact with dirt inside the car. CD covers, used tissues, old maps and lighters parties are the main objects responsible for spreading germs.

The survey found that about 60% of drivers are totally unaware that the waste found inside their cars are a health risk.

Nygiene provides the car, beyond the classical properties of a coating, an additional feature of self-cleaning, easy to clean, antibacterial and anti-fouling. Under the incidence of sunlight, effectively inhibits the existence of bacteria, viruses, fungi and spores on the surface preventing it from becoming a means of transmitting infections.

Not only penetrates deeper into the surface of the paint to provide a better protection, but also provides a long-term germicidal effect to the surface of the articles.

Services

Surfaces hygienization

By placing nygiene a surface is to coat it with titanium dioxide. When in contact with the light (natural or artificial), it activates the release coating strong oxidant will eliminate odors and kill viruses and killing bacteria and improve air quality.

Application protocol:

1) Collect a sample of the surface to be analyzed to know the initial microbial count using the standard plate count method.
2) Next, is done the photocatalytic antimicrobial coating (with electrostatic guns) on the surface. During the coating of surfaces, you must devide two areas: the area where was the initial sample taken will be marked as "control" and the second will be marked as "test" and held the photocatalytic coating with antimicrobial compound.
3) The coated surface should not be touched during the next hour after its application to ensure it has dried completely.
4) A lamp must be connected to ensure a light irradiation.
5) After 4h should be withdrawn a new sample from the surface to find the microbial count.
6) Subsequently, new samples must be taken every 2 hours for analyzing the microbial load.

**Procedure for the surfaces sterilization**

![Diagram showing surfaces sterilization](image)

**Electrostatic guns:**

The application of nygiene on surfaces will be held with electrostatic guns. Electrostatic guns offer excellent quality workmanship and material savings, with the added benefit of easy modular installation.

Advantages of using electrostatic gun:

1) Material saving
2) Best finish
3) Operator Comfort
4) Save time
5) Durability
**Air hygienization | Lamp**

nygiene is a lamp that illuminates while also cleans, purifies and deodorizes any environment without using chemicals. The nygiene lamp is coated with titanium dioxide. When the light is turned on, the external coating is activated, releasing strong oxidizers that will eliminate odors and kill viruses killing bacteria and improving air quality.

In essence, nygiene appears as a simple, safe and economical solution to constantly sanitize any environment without using harmful chemicals. Through this process, it is avoided that Infectious diseases, viruses and bacteria spread, while maintaining the level of microbes in the home environment to a safe level. It also prevents the growth of colonies of bacteria and helps to reduce pollution and carbon emissions, fighting global warming. Some of the microorganisms which can not resist the nygiene hygienization are bacteria, viruses, fungi, mold and dust mites.

**Application protocol**

**Air hygienization process indoors:**

1) Take an air sample indoors using the samples checker Hi Media air sampler (Complies with European standard ISO / TC 209) 71.
2) Change to the nygiene lamp and wait for 2 hours, then take another air sample collection to find the reduction of the bacterial count.
3) Subsequently collecte samples when pressed 4h, 6h, and so on up to 24 h.
Air samples verifier Hi Media

- Place prepared plate in position (without lid)
- Vertical Mounting
- Horizontal Mounting
## Analysis models of air purification levels

### No. of lamps: 1

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<th>No. of UFC at t=4</th>
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<td>ICU</td>
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Air hygienization | Sticker

The nygiene sticker is coated with titanium dioxide. When in contact with sunlight, it activates the coating that releases strong oxidants that will eliminate odors, kill viruses and deadly bacteria, improving air quality and protecting from the UV penetration.

The nygiene sticker has a protective layer that works both as a disinfectant, cleaner and deodorizer that provides everyone with a simple, safe and affordable solution to get a cleaning continues surrounding your car without the use of harmful chemicals.

Self-cleaning

The fogging effect that occurs in the windows of cars is caused by condensation of water that forms small drops on the surface.

The degree of water repellency on a surface of a specific material can be measured by the contact angle with water. The hydrophilic effect of TiO₂ is produced when the surface is exposed to UV light. After a certain time with subdued lighting the contact angle approaches zero.

By preventing the formation of water droplets - which contribute to the surface to fog - the nygiene sticker will preclude fogging of car windows.

Cars can stay clean only to the action of sunlight and rainwater due to photocatalytic and hydrophilic properties of titanium dioxide. We can not say that the car will never be dirty because the self-cleaning process is dependent on the lighting conditions, rainfall and accumulation of dirt, but it is a fact that the nygiene sticker will slow the rate of contamination of surfaces, saving considerable time and money in maintenance and cleaning operations.

Bacteria, viruses and fungi are killed within minutes of contact. The effect of TiO₂ nano-particles in bacteria is very important, since they constitute the lowest level in the food chain from the ecosystem. The TiO₂ nanoparticles are the new generation of advanced materials: have less than 100 nm in diameter and optical properties, dielectric and photocatalytic.

Application protocol

Air hygienization process in cars:

1) Take an air sample in the car using the samples checker Hi Media air sampler.
2) Place the nygiene sticker on the windscreen of your car and wait for 2 hours, then collect another air sample to find the reduction in bacterial count.
3) Subsequently collecte samples when past 4pm, 6pm and so on up to 24 hours.