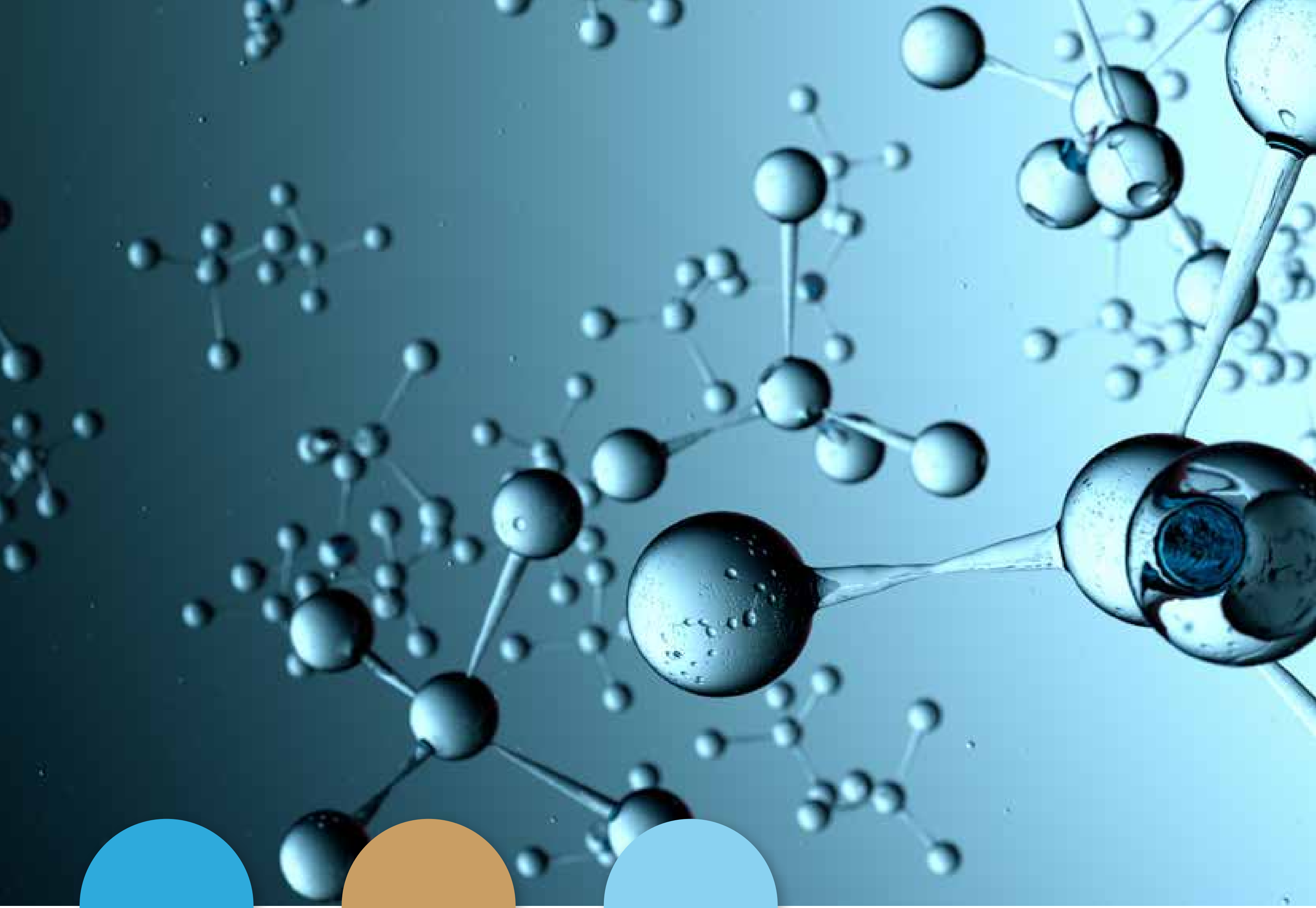


Photocatalytic Lamps:
The Air Clean LED Lighting (ACLL) System

A technology for purification of the environment and energy efficiency.

N·O·K·A
Sustainable Efficiency

THE ACLL SYSTEM

ACLL is a lighting system that integrates LED technology with the nanotechnology to produce a solution for energy efficiency and environmental purification.

ACLL is made up of LED lamps treated with nanomaterials that trigger a photocatalysis process capable of eliminating over 90% of viruses, bacteria and other polluting organic substances present in the environment. The purification process is always active when the lamp is turned on.

The ACLL system's LED technology also results in an efficient lighting system, allowing for the optimization of energy consumption.

HOW IT WORKS

The system made up of LED lamps treated with nanomaterials that trigger an environmental purification process when the lamp is turned on. When the lamps are switched on, a photocatalysis process is activated that allows tungsten trioxide (WO3) molecules, appropriately mixed with platinum and other substances (including the primer that allows for their application and coating on the lamp surfaces), to act as a photocatalyst, generating reactive oxygen species (ROS), which are elements that can transform the harmful organic substances into harmless inorganic molecules (H2O and CO2).

The basic nanomaterial is patented, while the solution applied to the lamp surfaces is mixed specifically for each type of lamp, with precise requirements set in relation to the lamp's material and surface size. The system also considers the specific LED light emission spectrum.

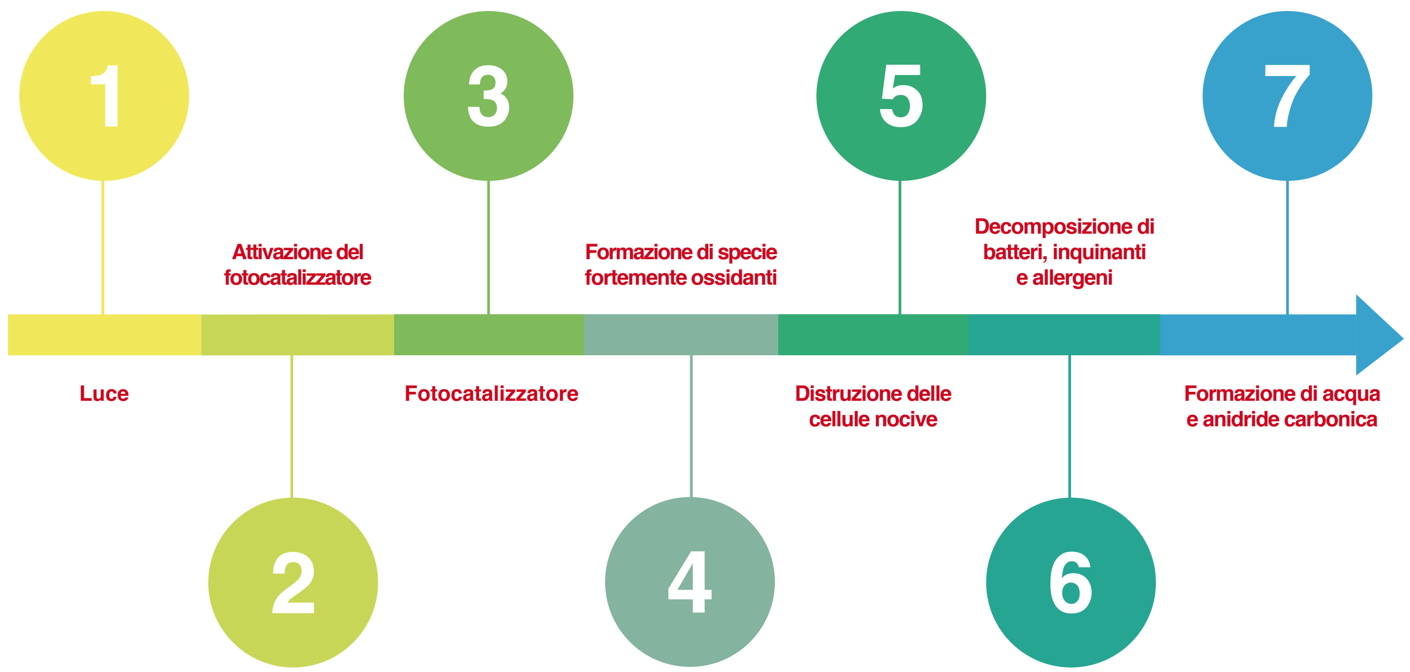
The use of appropriate lamps with LED technology, coupled with a photocatalyst such as tungsten trioxide, allows for achieving the most effective photocatalysis, being able to count on the emission of light in the visible spectrum and thereby overcoming the lighting limit with UV rays that is instead required with a photocatalyst such as titanium dioxide.

The lamps thus take on biocide characteristics, and, in following the laws and regulations governing the sectors for application, may be considered as a guarantee for definitive sanitization.

N·O·K·A NANOTECH

Air Clean LED Lighting (ACLL) è l'innovazione, sviluppata da Noka S.r.l. congiuntamente a Noka Nanotech, nell'ambito dell'efficienza energetica e della sanificazione che abbina nanomateriali a base di nanosilici WO3 e Platino con specifici modelli di lampade LED per ottenere un duplice effetto: efficienza nei consumi energetici e purificazione dell'aria.

Oggetto di deposito domanda di Brevetto n. 102016000036943



BENEFITS

CONSUMPTION
Energy efficiency and duration

The employment of the ACLL products that use LED technology allows for obtaining important and significant savings in terms of electricity consumption, when compared with traditional lighting systems. Electricity consumption can be reduced by 60%-90%, with a consequent reduction of the related costs.

Given the long life of the lamps used (from 50,000 to 100,000 hours), it is also possible to achieve important savings on substitution and maintenance costs when compared with traditional systems..

VIRUSES AND BACTERIA
Antibacterial and antiviral effects

ACLL allows for eliminating many types of viruses and many bacteria, whether they are Gram-negative (E. Coli) or Gram-positive (such as staphylococcus aureus, which can lead to food poisoning). Tests conducted in specialized laboratories show reductions of the bacteria population, ranging from 98% to 99%.

ODOURS
Elimination of odours

ACLL also eliminates many bad odours caused by bacteria or odorant molecules dissolved in the air, coming from daily activity or human presence.

VOLATILE ORGANIC COMPOUNDS (VOCs)
Elimination of air pollution

ACLL also eliminates organic substances dissolved in the air. As shown by a test conducted on VOCs with up to 14 different components, the ACLL system reduces such compounds by more than 60% after 180 minutes.

SECURITY

With the photocatalysis (see chart below), the treatment of the air occurs by contact, without any emission of substances in the environment: this makes it possible to achieve purification objectives while also ensuring maximum safety for humans.

The reduction of bacteria, viruses and other substances occurs with an oxidation mechanism that produces only very small quantities of water and carbon dioxide.

ACLL is safe, and is favourable to hygiene for both humans and animals

ACLL is useful for people suffering from allergies, because it eliminates the most important causes of allergy.

ACLL is non-toxic and does not inject harmful substances into the environment.

The photocatalyst produced does not contain any substances classified as dangerous for health or the environment, as defined by the provisions of Directive 67/548/CEE and/or the Regulations (CE) 1272/2008 (CLP), and subsequent modifications and additions.

PRODUCTS AND MATERIALS

LED lamps
All of the lamps used for the photocatalytic applications of the ACLL line have been designed specifically for the purpose of producing the best illuminance of the environment and the most effectiveness in terms of air purification.

The principal distinctive characteristics are:

1. The largest possible surface of the bulb treated with the photocatalyst
2. Use of LEDs with emission, in the visible light spectrum, that ensures:

    - Optimal illuminance
    - Visual comfort
    - Effectiveness in the activation of the photocatalyst used.

Photocatalyst
The nanostructured photocatalyst used in the treatment of the lamp surface is made up of tungsten trioxide (WO_3) mixed with platinum, silica, methanol, and water.
It is a photocatalyst sensitive to visible light with a decomposition capacity that is up to 20 times greater than that of titanium dioxide (TiO_2).
Testing has verified the antibacterial effectiveness of the ACLL system with respect to: E. Coli, Staphylococcus aureus, Legionella pneumophila, and cladosporium cladosporioides.

TESTS AND ANALYSES

The analysis of the effectiveness of the process activated by the LED lamps treated with photocatalytic nanomaterials serving as the basis of the ACLL system was conducted at a leading laboratory specialized in nanotechnologies.

The purpose of the test was to verify the radiation-induced oxidizing power of the sample of tungsten-trioxide-based photocatalytic material in getting rid of volatile organic substances (acetaldehyde and mix of VOCs) and bacterial strains in conditions of illumination with visible LED light (lamp supplied by the contractor).

Results: bacterial load
After 48 hours of irradiation, a sizeable decrease of the bacterial population was seen in the samples treated with the photocatalyst vis-à-vis the untreated sample.

A: Average value of micro-organisms non-photocatalytic material after inoculatio;
N: N. inoculation micro-organisms;
BL: Average value of micro-organisms,non-photocatalytic material with irradiatio
CL: Average value of micro-organisms, photocatalytic material with irradiation.

Gram-negative bacteria (E.Coli)

Specimen	A	N	BL	CL	R log	% Reduction
1) Blank (control)	3,40E+04	1,80E+06	7,50E+05			
3) W treatment				1,60E+04	1,67	97,9%

Gram-positive bacteria (S. Aureus)

Specimen	A	N	BL	CL	R log	% Reduction
1) Blank (control)	1,90E+04	1,20E+06	4,20E+05			
3) W treatment				6,00E+04	1,84	98,6%

TESTS AND ANALYSES

Results: VOCs

The test conducted with the tungsten-trioxide-based photocatalyst demonstrated the photo-induced degradation with respect to the analytes monitored

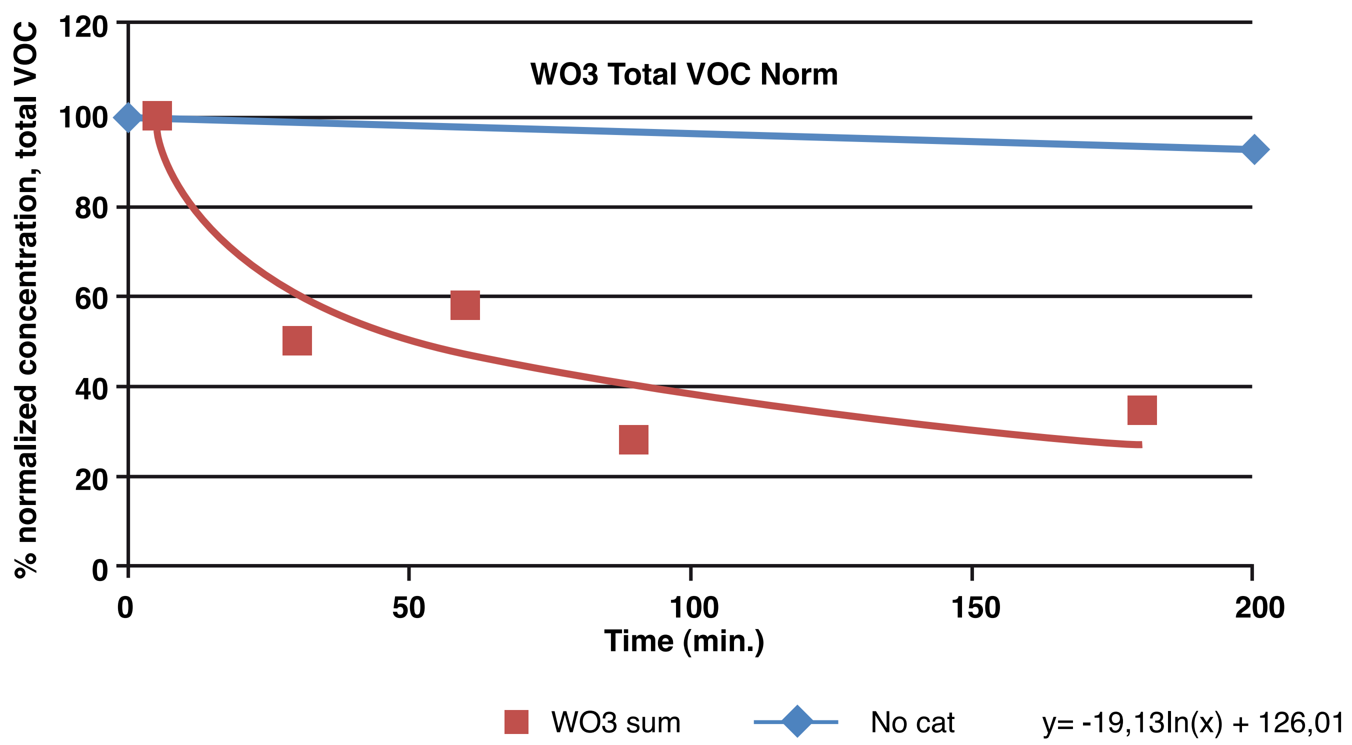
A trend is observed in the decrease of the concentrations of each VOC, each with differing speed (an indication of the fact that a radical degradation is actually being measured). By plotting the sum of the signals of the analytes against a blank (see graph below), it is possible to obtain a general trend that can be replicated with a logarithmic function.

The data for the mathematical extrapolation of the curve obtained are the percentage decreases reported in the table, which can be quantified (actually improperly) at approximately /4800/m2 per hour in the first hour, for the conditions adopted in the test.

Time (min)	% Decrease
0	0%
60	-33,70%
120	-52,10%
180	-62,90%

Tabella variazioni relative alla concentrazione totale di VOC, espresse come percentuale sul totale

Variazione della concentrazione percentuale di VOC totale, normalizzata e confrontata con un "bianco" (stesse condizioni del test, ma senza alcun fotocatalizzatore)



POLLUTION AND ADVANCED OXIDATION PROCESSES

Industrial development, increased emissions of combustion products, and the extension of urban areas are some of the causes of one of society's most severe problems: air and water pollution.

The objective of reducing pollution must begin from effective prevention measures, but it is possible to act successfully through the use of air and water purification technologies in order to make the environment healthier and more hygienic.

Different methods exist for fluid purification:

- The air can be purified with traditional methods such as activated carbon absorption (exploiting the characteristics of the materials for removing pollutants from air flow) or thermal incineration (a process where the pollutant is put into a burner and heated to the point of triggering its complete combustion to carbon dioxide and water)
- The purification of water, after a series of preventive treatments (screening, sand blasting, de-oiling, and so forth) is carried out in biological oxidation tanks through the use of activated sludge and of an aerated environment.

The most recent, innovative technologies for purification include advanced oxidation processes (AOP). The AOP are chemical processes with high oxidizing power capable of breaking down the molecules of the pollutants present in the atmosphere or water, by transforming them into harmless biodegradable molecules.

Photocatalysis is actually one of the main advanced oxidation processes.

PHOTOCATALYSIS

Photocatalysis is a catalytic method applied to photochemical reactions, conducted with the aid of a photocatalyst that exerts its action when irradiated with radiation of an appropriate wavelength.

A photocatalyst is a substance that causes the activation energy of a specific reaction to decrease and thereby causes the speed of such reaction to accelerate.

In essence, the chemical process underlying photocatalysis is an oxidation that begins due to the combined action of light (solar or artificial) and air. In this regard, photocatalysis replicates one of simplest natural processes, namely, photosynthesis.

The process of photosynthesis of plants is actually a typical example of photocatalysis.

In comparison with photosynthesis, in which chlorophyll captures solar light to transform water and carbon dioxide into oxygen and glucose, photocatalysis (in the presence of a photocatalyst and light) generates an oxidizing agent capable of transforming organic substances present in the air into carbon dioxide and water.

Photocatalysis not only kills bacteria cells, but it also decomposes them.

Based on testing, tungsten trioxide is more effective than any other antibacterial agent (and other photocatalytic materials, such as titanium dioxide, which react mainly to UV rays) because the photocatalytic reaction – with the light in the visible spectrum – occurs also when there are cells that cover surfaces and the multiplication of bacteria is active.

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