Safer environments

New technologies counteract the spread of thanks to innovative applications, including fabrics and ceramic coverings with antimicrobial properties

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Microbial contamination represents a global public health issue, made more acute and evident by particular contingent conditions (covid pandemic). Various infectious agents, such as viruses, bacteria, protozoa and fungi, can in fact contaminate surfaces and living environments, posing a real health risk. The danger concerns not only respiratory viruses, but also emerging infectious agents, an aspect amplified by the phenomenon of resistance to antibiotics and disinfectants, a factor which has increased interest in the study of innovative sanitisation techniques.
Conventional methods, based on the use of chemicals, have been called into question due to increasing exposure of the population and dispersion in the environment. In particular, these chemicals, during reaction, develop disinfection by-products, which could have undesirable effects, so scientific research has considered alternative strategies and developed innovative methods.

Scientific research and industrial development are committed to producing “green” technologies able to enhance disinfection in a sustainable way

New “green” technologies

The introduction of new technologies which are friendlier to humans and the environment promises to help control biohazards and overcome certain critical issues. Hence, scientific research and industrial development are engaged on a daily basis in the realisation of "green", compatible and sustainable technologies able to enhance disinfection in an environmentally safe manner. Among the new proposals, a particularly important role is played by **photocatalytic technologies**.

What is photocatalysis?

The first studies on photocatalysis date back to 1972, when researchers ascertained the photocatalytic effect of **titanium dioxide**, a chemical compound in the form of a colourless crystalline powder. As defined by the **International Union of Pure and Applied Chemistry (IUPAC**) in 1997, photocatalysis is "the change in the rate of a chemical reaction (or its initiation) under the action of ultraviolet, visible or infrared radiation in the presence of a substance, i.e. the photocatalyst, which absorbs light and is involved in the chemical transformation of reaction components". Thus, through air, light and water, an oxidative process is triggered that is eventually able to attack bacterial molecules but also to act on certain polluting compounds, neutralising them.

Indeed, the photocatalytic process generates reactive oxygen species (or free radicals) that can cause the degradation of various groups of organic and inorganic compounds, as well as being able to inactivate pathogenic micro-organisms. The antimicrobial mechanism produced by photocatalysis is not yet fully explained, but it can lead to damage to the bacterial cell or membrane and to alterations of macromolecules, such as proteins.

An innovative solution involves the creation of new advanced materials consisting of ceramics with a light-enhanced antimicrobial capacity

Which applications?

Since the 1970s, various studies have been conducted on the use of photocatalysis for various purposes, including environmental clean-up, air, water and soil purification, and **self-disinfection**.

Applications have been considered for high-risk areas such as hospital environments, but also for recreational, sporting, and various outdoor and indoor locations.

The applications of photocatalysis also extend to **textiles** and **personal protective equipment** such as the masks used to combat airborne contamination. In this field, the use of photocatalytic materials has shown itself to be a protective measure. also increasing durability and extending use, while at the same time favouring recycling and reducing dispersion in the environment.

Photocatalysis has also been applied in **open spaces** for the treatment of air pollutants, with reference not only to the reduction of microbial contamination, but also of certain chemical pollutants. Some **paints**, used for walls or artistic works such as murals, have been engineered to achieve these sanitising effects.

The mechanism of virus inactivation by photocatalysis is still to be clarified, but the effectiveness of the system has already been demonstrated in several laboratory tests, using numerous types of micro-organisms, including Sars-CoV-2.

The use of nano- and microparticles

Application in the coating of surfaces in various environments allows not only conferring interesting antimicrobial properties, but also activating self-disinfection mechanisms, thus helping to **reduce the risk of spreading certain infectious diseases** and favouring, in any case, the maintenance of a low microbial load. Various nano-technologies (one-billionth of a metre in size) have also been developed to enhance these coatings, but recent studies show that antimicrobial action is also present at micrometric level (one millionth of a metre). This aspect is also very relevant to safety, since nanoparticles have been associated with possible health risks, so having photocatalytic materials 1000 times larger (around one micron) represents an opportunity of great interest, not only scientific or industrial, but also for members of the public and the environments they live in on a daily basis, and in which they carry out recreational and work activities.

Ceramic materials

One technological challenge concerns how to place these materials on different types of surfaces, such as **floors, furniture, walls, pipes, basins and tubs**. Various solutions have been developed. Among these, an extremely innovative and promising one concerns the realisation of new advanced materials made of **ceramics with a light-enhanced antimicrobial capacity (e.g. Advance ceramic tiles produced by Italcer in micrometric form**). This result is of particular interest, both due to the strength of these materials and to their ductility in applications for floors and walls of various structures, and various types of environments, both outdoor and indoor.

What does the future hold?

The various materials used as photocatalysts include Titanium Dioxide, Iron Oxides, Zinc Oxide, Tungsten Trioxide and Tin Dioxide. Each has certain limitations and of these, Titanium Dioxide is considered one of the best candidates for several reasons, including stability and low cost. However, it too has limitations, such as possible toxicity at nanoparticle level and often the need to use ultraviolet light to achieve greater effectiveness. Ultraviolet rays, while desirable for stimulating the production of vitamin D and promoting tanning, at the frequencies used for disinfection can be potentially carcinogenic, so they are difficult to use wherever there are people. Light, on the other hand, is not denied to anyone and is part of various daily activities, both solar and artificial. Therefore, the development of new photocatalysts is desirable, and research is moving towards materials that can overcome the limits of those currently known and already available.

Of particular relevance is the development of photocatalysts which are active in visible light or even in lightless conditions, and fixed on different types of substrates. Particularly promising among these are **innovative ceramics**, which are applicable due to their stability, durability and versatility in various sectors, including the context of air and water treatment, through specially engineered devices.

Recent studies have shown that the abatement activity of micro-organisms can be further enhanced by the simultaneous presence of other anti-microbial agents such as silicas and glassy substances containing copper and silver ions, or products containing metallic silver complex, which act as an additional reservoir of active substances capable of attacking micro-organisms. New molecules and chemical-physical processes for fixing them are constantly being developed and experimented in various research centres, including in Italy.

The preliminary results obtained so far by the various researchers in this field are promising and make it desirable to carry out further studies to assess and optimise the various parameters involved in the photocatalytic process. The aim of this scientific progress is to make this technology even more effective, on a par with traditional and already established disinfection methods, but with an increasing tendency to achieve greater sustainability, both for people and the environment. At present, antimicrobial materials cannot replace classical disinfection methods, but they represent a promising opportunity, especially in environments where the microbial load must be kept under control due to the activities carried out there, or to fulfil special hygiene requirements, or simply to improve the healthiness of spaces where fragile people reside.

Antimicrobial materials represent a promising opportunity especially in environments where microbial loads must be kept under control

All these efforts and technological advances must not however oblige us to look at micro-organisms as if they were pathogens and enemies to be defeated. Rather, and more often than not, we should view them as allies to be lived with. Without microbes there would be no life, soils would not be fertile and plants would not be able to survive. We ourselves would not be able to survive without the many bacterial species that live in our body and protect it - as is the case with the many microflorae we host, including the microbiota in the gut, or in other tissues. Conversely, we need to reduce the use of anti-microbial chemical agents also known as “biocides”, which pollute and sometimes accumulate in the environment, often remaining there for generations. Learning to use the natural principles of disinfection, based on the presence of light and water molecules, is an advanced and sophisticated solution, but one that also takes us back to a sustainable perspective or, as we like to say now, makes us a little more “green”.