Importance of disinfectant residual activity

Esther Jansen discusses the emergence and relevance of disinfectant residual activity in hospitals, outlining the latest research around environmental transmission of pathogens and best practice for infection prevention.

Thousands of years ago, the Egyptians used wine or vinegar to clean surfaces. In the 1880s, Joseph Lister first used a phenol agent in his pioneering work on surgical antisepsis. Quaternary ammonium compounds (QACs) were not recognised as a disinfectant until the 1930s, and today are the most widely used disinfectant chemistry in the home and hospital. Chlorine, also known as bleach, has long been a disinfectant staple in the home and hospital. At high concentrations, chlorine can kill bacterial spores, but it is rarely used at these concentrations.

More recently, a wider choice of sporicidal disinfectants which can be used at lower and safer concentrations has emerged and these include chlorine dioxide (ClO_2), peracetic acid and hydrogen peroxide. Surface disinfectants are constantly evolving to support hospital staff in their battle against persistent harmful microorganisms and outbreaks. The incorporation of residual activity in surface disinfectants is one such innovation that has been emerging in the consumer space. This article aims to explain why disinfectants incorporating residual activity have a place in the hospital too.

Residual activity explained

Residual activity is defined as the capability of a disinfectant product to continue to produce a reduction in the number of viable cells of relevant test organisms on hard, non-porous surfaces. In the UK and Europe, a disinfectant's residual activity can be determined by PAS 2424:2014.

In early 2014, British chemicals company Byotrol recognised the need for a test method by which residual antimicrobial activity could be independently measured and assessed. However, there was no European or International Standard test methodology for assessing the residual antimicrobial activity of a chemical disinfectant or antimicrobial product.

The company collaborated with the British Standards Institution (BSI) to develop a consensus-based test method, as a BSI PAS. The PAS 2424:2014 test method considers that a surface will be touched multiple times between the time a disinfectant is first applied onto it until the next application (up to 24 hours after). The test method involves drying microorganisms and interfering substances onto a defined surface. This simulates a contaminated surface prior to the application of a disinfectant.

The disinfectant is then applied onto the surface. A series of three abrasion and re-contamination cycles are performed over a period of 24 hours, intended to simulate the high-touch exposure of the surface in between disinfectant application. The surviving microbes are measured to evaluate the disinfectant's residual activity.

Residual activity is relevant today because it tackles the repopulation of microorganisms on surfaces, especially those that are frequently touched such as door handles, elevator buttons, staircase rails, and touchscreens. Traditional disinfectant products provide protection for only a brief period and allow microorganisms to repopulate on the surface after every touch. By incorporating residual activity ingredients into these disinfectants, high-touch surfaces can be subjected to antimicrobial activity for prolonged periods of time and as such, patients can be protected for longer.

Residual activity can be combined with a variety of disinfectant chemicals to enhance performance by extending it. The strategic alliance between Microban International and Procter & Gamble resulted in the successful introduction of Microban 24, a product intended for the disinfection of high-touch surfaces in the home.

The active ingredient is based on QACs which provide an initial kill of at least 99.9% of bacteria and viruses, including viruses that cause common colds and the flu. Additionally, the product forms a protective shield on surfaces which keeps killing bacteria for up to 24 hours, even when those surfaces are touched multiple times.

Another example of a residual activity

innovation is Solvay's Actizone F5, a QAC-based solution that offers residue-free 24-hour surface protection, with the Actizone ingredient killing more than 99.9% of bacteria and viruses. A proprietary polymer called Actizone P5 provides antimicrobial protection for up to 24 hours, even when those surfaces are touched multiple times. This product's registration process was completed in the United States in October 2022.

Diversey commercialises a disinfectant called Degragerm 24 Shield. It is powered by an advanced polymer technology that uses QACs in a specific combination with a patented polymer and surfactant system to achieve residual surface sanitisation.

When applying a disinfectant with residual activity onto a surface, a multi-layer protective shield is formed. This shield is made up of amphicelles of a unique structure which makes them highly effective against microorganisms. This unique structure is formed through the combination of quaternary ammonium actives with a polymer. Amphicelles are nucleated micelles. "Nucleated" means that the amphicelles are formed around a central area, in this case the polymer. Put simply, micelles are a collection of tiny balls (or surfactant molecules, in this case the quaternary ammonium actives) that are dispersed in a liquid substance. When the amphicelles dry onto a surface, the shield that is formed can kill 99.9% of bacteria and viruses. The shield is invisible to the naked eye and cannot be felt by human hands, but it is lethal to microorganisms.

A disinfectant with residual activity combines an initial wet kill, as achieved by traditional disinfectants, with a prolonged dry kill. The wet kill is achieved during the disinfectant's contact time, typically achieving a 99.9999% Log reduction (Log 6) in the case of using a sporicidal agent. This initial wet kill is achieved by the disinfectant's active ingredient. The prolonged dry kill is achieved by the amphicelles, which can achieve a 99.9% Log reduction (Log 3) after application of the disinfectant. Standard disinfectants only kill on contact, allowing microorganisms to repopulate immediately after someone or something touches the surface repeatedly. Residual activity disinfectants place a protective shield over the surface. This shield activates powerful and continuous antimicrobial protection in small amounts over time, even when the surface has been touched multiple times.

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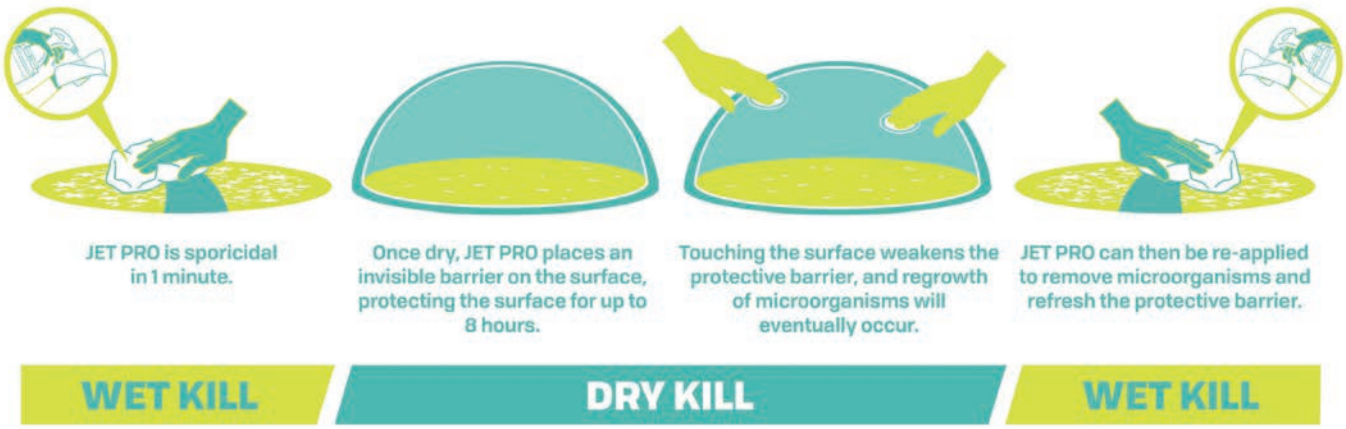
QACs provide a lower-level initial wet kill when compared to sporicides. QACs are so widely used in the home and in hospitals because of their stability and convenience. However, they have limitations. Firstly, microorganisms can develop resistance to QACs. Furthermore, spores are resistant to QACs because the coat and cortex of the spore act as a barrier. Mycobacteria possess a wax-like cell wall that denies access to the disinfectant. The outer membrane of Gram-negative bacteria acts as a barrier to the uptake of disinfectants. Because QACs are not sporicidal they cannot tackle the challenges of *Clostridioides difficile* (*C. diff)*.

There is another drawback with QAC-based products in that they are supplied as ready-to-use spray products or as pre-wetted wipes contained within tubs or flow wrap packs. These formats bring with them enormous convenience. The drawback, however, is that these pre-wetted plastic wipes and their packaging are made almost entirely of plastic. Multiple plastic wipes are pulled from their packaging, used once and then thrown away. This means that the use of QACs can result in an unsustainable approach to infection prevention and control.

Sporicidal disinfectants provide a higher-level initial wet kill. Today, they are not used in the home. However, in a hospital, sporicidal disinfectants have traditionally been deployed because of their greater efficacy in critical areas such as intensive care units, operating theatres, and isolation wards to protect the most vulnerable patients.

Sporicidal disinfection has not yet been adopted for routine disinfection around the hospital, in part due to misconceptions around cost and safety. Sporicidal disinfectants are believed to be expensive and highly concentrated if they are to achieve high-level disinfection, though this is not true for all sporicidal disinfectants available today.

It is scientifically proven that microorganisms cannot build resistance to an oxidising agent such as chlorine dioxide (ClO_2). The biocidal activity of ClO_2 is attributed to its oxidative action against microbes. ClO_2 destroys pathogens via electron exchange, sequestering electrons from the microorganism's vital structures such as cell walls, membranes, organelles, and genetic materials. This causes a molecular imbalance leading to the microorganism's death. Unlike non-oxidising agents such as QACs, ▶



microorganisms cannot develop resistance to ClO_2 because they are destroyed completely. In addition, ClO_2 is widely regarded as one of the most effective disinfectants for biofilm removal and prevention.

In October 2022, Jincy Jerry (assistant director of nursing in infection prevention and control at the Mater Misericordiae University Hospital in Dublin) shared her published research at IP2022, the annual conference of the UK's Infection Prevention Society (IPS). The daily use of a chlorine dioxide-based sporicidal product and UV (ultraviolet) disinfection was proposed as the most cost-effective single infection control strategy. This strategy enabled the hospital to achieve three consecutive years without outbreaks of Carbapenemase Producing *Enterobacteriaceae* (CPE), Vancomycin-resistant *Enterococcus* (VRE), Norovirus, and *Clostridioides difficile* (*C. diff.*).

QACs have been combined with ingredients providing residual activity. Sporicidal agents, which are superior to QACs, can be combined with these ingredients too, and British infection prevention specialist Tristel has successfully achieved this. JET PRO is a chlorine dioxide-based sporicidal foam for surfaces which incorporates Actizone residual activity technology. The active ingredient chlorine dioxide achieves the initial wet kill up to sporicidal level according to EN 17126 in 1 minute. Once dry, a protective shield is formed that continues to kill bacteria and enveloped viruses for up to 8 hours, even after multiple touches. The purpose of the product is not only to protect surfaces, but to protect patients.

Sustainable disinfection

A patented formulation is available in a variety of sustainable infection prevention and control solutions, such as a chlorine dioxide foam delivered in a proprietary dual-compartment, recyclable bottle paired with reusable trigger heads – or a dual-compartment, recyclable capsule which requires 97% less plastic packaging than pre-wetted plastic surface wipes.

One of the two compartments contains citric acid and the other contains sodium chlorite. The active ingredient chlorine dioxide is generated when the two ingredients are combined at point of use. All packaging is recyclable and reusable. But recycling and re-using is not enough. Disinfectant manufacturers must take innovation further to truly support hospitals achieve their "go green" targets.

Tristel has recently launched the Cache Collection, a new range of sporicidal surface disinfectants. These innovations provide a sustainable alternative to products such as pre-wetted, single-use plastic surface wipes. Cache disinfectants separate the liquid disinfectant from the spreader (the wipe), enabling the hospital to eliminate single-use plastic surface wipes and choose a sustainable spreader option such as paper, bamboo, or organic cotton instead.

The paper towel is the reference material in EN 16615, and when passed any spreader can be used to spread the disinfectant onto the surface. Pre-wetted, single-use plastic surface wipes can be eliminated.

How well a disinfectant performs not only depends on its active and added ingredients. It also depends on the delivery method and on the substrate that is used to apply and spread the disinfectant on the surface. EN 16615, also referred to as the 4-Field Test, is the European Norm used to measure the efficacy of a chemical disinfectant applied by wiping. Scientists selected the "Tork Blue Wipe" as an example of wipe substrate in the medical area. When demonstrating efficacy, a disinfectant can be applied with any type of dry wipe. Using a chemical disinfectant with an EN 16615-pass makes the choice of spreader, the medium chosen to distribute the liquid over the surface, infinite. A spreader made of plastic need no longer be a necessity; it can be eliminated.

There are claims that using a microfibre cloth with water is sufficient to achieve a certain level of disinfection. If one were to take a closer look at a microfibre cloth with a microscope, a multitude of tiny tentacles or hooks would be revealed. When a hand presses a microfibre cloth onto a surface to wipe it, the tiny hooks "scratch" the surface to catch contamination. This contamination comprises both visible (dirt) and invisible (microbiological) contamination.

However, microbiological contamination is not removed entirely if the spreader does not carry at least some liquid with disinfection properties. Water alone, even in combination with a microfibre cloth, is simply insufficient. Yes, hospitals need to become more eco-friendly, but that is not synonymous with expelling chemicals. Not all chemicals are harmful to the environment.

As briefly touched upon before, sporicidal efficacy is not synonymous with aggressive chemicals. One of the strengths of chlorine dioxide is that it is effective at low concentrations. Sporicidal efficacy is assessed by means of EN 17126. Since its release in 2018, disinfectant products claiming sporicidal efficacy within the medical area should no longer be testing to EN 13704. The combination of EN 17126 compliant sporicidal efficacy with an EN 16615 pass to enable the use of sustainable spreaders, eco-conscious packaging and delivery formats and residual activity results in a sustainable approach to disinfection, with sustainable referring to both the environment and long-lasting efficacy.

A disinfectant's residual activity may be misconstrued as a reason to disinfect less. The protective shield is there to stop bacteria and viruses from repopulating after multiple touches. That is correct, but the shield expires nonetheless depending on how often and how intensely the surface is touched. The shield provides the reassurance that it continues to act even when the user has moved on to their next task. The disinfectant works as hard as the person who applied it, protecting patients in all areas of the hospital. With staff shortages being a persistent issue in many a health service, patients remain protected by the impact one nurse can make. This unique collaboration between nurse and disinfectant results in powerful and prolonged patient protection. CSJ

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About the author

Esther Jansen graduated from Zuyd University (Maastricht, NL) in International Business & Languages (BA) in 2007, and from Lord Ashcroft International Business School (Cambridge, UK) in Marketing & Innovation (MA) in 2008.
As part of her career with Tristel, Esther has been stationed in the UK, Spain, Hong Kong, Shanghai and the Netherlands, developing a broad understanding of different healthcare settings and the challenges they face. Esther has 14 years' experience in the medical device decontamination industry. She currently works for infection prevention company Tristel as group head of marketing communications.