Destruction of Microbial Growth and Prevention of Survival in Buildings by Surface Modification

A White Paper from Design1 Indoor Environmental Inspections

Introduction

The news is filled with stories about sickness caused by microbes. We have all become accustomed to terms like MRSA, SARS, H1N1, *E. coli*, *C. difficile*, Legionnaire's Disease, Norwalk virus, toxic black mould and others. Most of us haven't any real understanding what these things are and have even less understanding of what to do about them. One thing is certain – the concern is increasing.

If we can go into space we might presume that we are winning the battle against the microbes. We are not. Why?

Microbes are a fact of life. We are surrounded by them – they are on our bodies, on the things that we use in everyday life, and in the air and environment that surrounds us. Most of them are irrelevant to us, neither good nor bad, but just there. No strategy to control them is needed.

However, some microbes have implications to human health because they can cause disease, exacerbate allergic and asthmatic conditions, cause toxic reactions, or just make us unhappy because they smell and deteriorate our environment that surrounds us. A few more common examples include:

- Skin-borne bacteria that can cause infections in cuts and abrasions – methicillin resistant *Staphylococcus aureus* (MRSA) is a well-publicised example.

- Environmental bacteria such as *Legionella pneumophila* that can colonise building ventilation systems and result in Legionnaire's disease through exposure.

- Various viruses (with numerous strains of influenza viruses being the most common) that can be passed from person to person by contact with commonly-touched surfaces in buildings like door knobs and light switches and that can cause significant health problems.

- Kinds of mould such as *Penicillium, Aspergillus* and *Stachybotrys* that can live on damp surfaces and in humid environments that can cause musty odours, building surface deterioration and a wide variety of human responses including headaches, sinus infections, skin irritations and allergic reactions.

Dealing with illnesses that result from exposure to these organisms is the realm of the medical community. We, as consumers, need effective ways to reduce exposure before we contact diseases and have detrimental health effects. We all can have a very important role to play in reducing the exposure of people to harmful microorganisms.

Kinds of Microbes

For the purposes of this paper, microbes can be divided into two main groups based upon how they react with surfaces. These include:

- Microbes such mould and some types of bacteria that colonise and then live on surfaces that we touch and are exposed to. Example include:
    - Bacteria living on building surfaces such as air conditioning and dehumidifier cooling coils, wet insulation, pool decks, wet clothing such as socks, garbage chutes and sporting equipment.
    - Fungi – mainly species of mould – that live on building materials exposed to dampness and high humidity, in crawl spaces, on our furniture, and on outdoor equipment and fabrics that remain chronically wet.

- Microbes such as bacteria and viruses that do not colonise the environment around us but come from us and that can be present on environmental surfaces from deposition from other places – from hand contact and from the air – and can remain alive long enough to infect someone who then removes them from the surface by hand contact. The most newsworthy types are in this group – MRSA, bird flu, SARS, Norovirus and others. This group of organisms includes that ones that humans typically refer to as "germs".

These categories are not scientific groups but simply are ways to look at microbes that are needed when trying to figure out effective means to control them.

Requirements of Microbes

Microbes are not particularly demanding – they like the same environments that we do. Conditions of temperature and humidity suitable to us are also suitable to microbes.

From the perspective of humans and our potential exposure routes, the *growth* of microbes on environmental surfaces really just requires a suitable surface with sufficient water availability. *Survival* of microbes (ie germs) for long enough for us to make contact with them requires only a suitable surface for them to remain on. Accordingly, our efforts have correctly focussed on surfaces.

Existing Control Methods

Cleaning has been the most commonly used means to control microbes that is easily accessible to most people. Intuitively, keeping surfaces clean is paramount to reducing exposure to germs. A huge industry has developed around this concept with every grocery, hardware and drugstore selling an endless array of cleaners, sanitisers, disinfectants, wipes, brooms, mops and other devices specifically sold to help control exposure to germs. This industry has mainly targeted "germophobia" and has not focussed much on surface growth. Hand cleaners have been a large part of this effort with most boasting an effective kill rate of better than 99%.

Reducing dampness and humidity has also been a main microbial control strategy. Use of dehumidifiers, air exchangers, fans and ventilation systems have all increased in popularity as a

means to reduce the damp conditions that are suitable to allow the growth of microbes on environmental surfaces.

Some consumer products are manufactured with microbial defence mechanisms in place. Plastics can be manufactured with built-in antimicrobial products, metals can be factory-treated with surface coatings of protective metal ions, and paints for use in damp areas are manufactured with products toxic to mould growth.

The responses that we have to microbes are the result of three main factors:

- Virulence. Some microbes are simply more dangerous than others. Our control strategies can do little to address this – they are what they are.

- Susceptibility. Some people are simply more susceptible to developing heath issues with exposure. Cleaning and control strategies cannot address this either.

- Dose. This is the one factor over which we should have control – reduction of exposure by reduction of numbers of germs and other microbes accumulating on and growing on surfaces is the focus of our cleaning efforts.

As noted earlier, with all of these strategies in place and readily available to almost everybody, one would presume that the battle against the microbes is being won.

But it is not. Why?

Limitations of Existing Methods

Existing methods to control microbes suffer from a few main obstacles that limit their effectiveness. These include:

1. No lasting effect. Cleaning, surface disinfection and hand washing all have this inherent limitation – the newly-cleaned surface can and will be contacted by microbes virtually immediately after cleaning and those new microbes will not be destroyed because the cleaning does not provide lasting defence, either because it evaporates or is simply removed by wiping it away. Surface disinfection and hand washing has tremendous value in removing existing germs but first contact after cleaning with a dirty surface will replace them fairly quickly. To be effective, surface disinfection would need to be done very often.

2. Lack of practicability. Some surfaces are simply not easily cleaned often enough to make much difference. We can wash our hands often, but we seldom clean our ventilation systems, sporting equipment and building surfaces often enough to prevent the growth of microbes and accumulation of germs.

3. Adaptation. Microbes, like all organisms, have mutations. Because of their very short reproductive periods, mutations are frequent. Some of them, unfortunately, are useful to the microbes and permit the microbes to survive in ever-increasing doses of the chemicals that we use to try to kill them. We have all heard of the term “super bugs” –

this expression is simply a name that has been used to describe microbes that have developed resistance to our defence products. Most products developed to kill microbes rely on poisoning – the alcohol content of hand sanitisers is an excellent example. Chemicals in commercially available disinfectant sprays, wipes and paints are other examples. They work by entering the organisms and poisoning some life process. If organisms develop tolerance to this through mutations, and the tolerance is genetic, this will be passed on to future generations, reducing the effectiveness of our defence. Charles Darwin called this process "evolution". Ultimately, the defence no longer is effective. The medical community has faced challenges with this.

4. Cost. Fighting a war against microbes can be expensive, especially if you want to win. Control of humidity, provision of fresh air, replacement of products and use of disinfectants and sanitisers all add cost to our control strategy. The cost includes both the products being used and the time required to use them. Often, the cost is prohibitive and, as a result, the defence simply isn't good enough.

Our main efforts have always focussed on:

- removal of microbes from surfaces – principally to control bacteria and viruses that are passed about by hand contact.

- improvement of conditions that support microbial growth - mainly for moulds and some environmental bacteria that like dampness.

- control of microbial survival by adding toxic chemicals to our products during manufacture – this is simply not practical for use on existing surfaces.

We simply need more choices.

Unless we are genetic engineers and have the means to change the virulence of organisms, or are biochemists with formulations that can selectively neutralise microbes of concern, our control methods need to focus on reducing exposure by reducing viable populations on the surfaces that surround us, particularly the high touch and high risk surfaces. The science behind this is already here.

Microbes do not need to be controlled on surfaces by poisoning. They can also be destroyed by physical contact with surfaces that can mechanically disrupt their delicate cell membranes. Cellular membranes in most microorganisms are very susceptible to electrostatic disruption. Once the membrane has been broken the organism will die soon after. The challenge is simply to modify a building surface such that cell membranes of microorganisms that contact it can be damaged without the modification being removed by routine cleaning. Like Achilles' heel, like Goliath's forehead, like the underbelly of Smaug, we don't need to mass poison the microbes, we just need to know where to direct the efforts.

We need a way to make a surface defend itself.

Disinfectants that would be used to control the growth and survival of microorganisms would ideally have the following characteristics:

- easily applied to existing surfaces
- not visible (colourless and odourless)
- durable and long lasting, even with repeated washing
- no toxicity to humans
- broad spectrum of effectiveness (should destroy a variety of organisms)
- does not promote adaptation
- compatible with all other cleaning products

Disinfectants can be divided into two major categories; bound and unbound. These terms simply refer to whether or not the antimicrobial has the capacity to molecularly bond to the surface on which it is applied.

An unbound product must diffuse or leach from the treated surface and be consumed by the microorganism to be effective. Most conventional antimicrobials, such as alcohol or quat-based consumer disinfectants, are intended to kill organisms on contact while wet and dissipate (evaporate) quickly to minimise the danger to humans, animals and treated objects. Hand cleaner is good example of this. Others use the time release capsule approach and obtain a longer working life by burying the antimicrobial in a paint, glue, binder or other coating and counting on slow migration to the surface. Certain types of bathroom paints fall into this category.

Once inside the organism, the chemical agent will act like a poison, interrupting some key metabolic, or life sustaining process of the cell and causing it to die. In all cases, once the antimicrobial is depleted or washed away during regular maintenance, protection vanishes.

A bound product, like the AEGIS Microbe Shield, forms a durable chemical bond upon application and remains chemically attached to the surface on which it is applied. It functions by electrostatically interrupting the organism's delicate cell membrane. This prevents microorganisms from carrying on vital life processes. The antimicrobial acts on contact with organisms and can do so again and again. One can think of the bound antimicrobial like a sword that is capable of repeated use. In comparison, a conventional antimicrobial treatment is more like a gun with limited ammunition. Since a bound antimicrobial is fixed to the surface it continually operates at full strength.

Unfortunately, a bit of chemistry is needed here as the chemistry of surface modification technology is unique. A conventional quaternary ammonium salt, a product which is the basis of many conventional antimicrobials, is chemically spliced to a silane molecule (silanes are used to hold heat shields on spacecraft), resulting in a highly active molecule that has both tenacious bonding capabilities as well as excellent antimicrobial properties. Once applied to a target surface it bonds everywhere, resulting in the creation of a large co-polymer involving the target and the treatment. Since there is no unused chemical once the water evaporates, there is no dislodgeable residue and no odour, leaching, off-gassing, migration or diffusion of the molecule can occur.

All other conventional antimicrobials used legally in Canada, including alcohols, quaternary ammonium compounds, bleach, peroxides, paint formulations, etc., work on the basis of either destroying what is present while the product is wet or by diffusing away from the treated surface over time. This promotes microbial adaptation and loss of activity. The AEGIS Microbe Shield is essentially permanent, and the problems associated with conventional chemicals are not of concern.

The AEGIS Microbe Shield is easily applied on virtually any surface by spraying or wiping. It is approved by the Pest Management Regulatory Agency of Health Canada for use on virtually all hard and soft surfaces found in building environments. It can easily be incorporated into existing cleaning and maintenance operations, providing a long-lasting defence to control the growth and survival of microbes on just about any surface. The modified surface will retain antimicrobial activity for an extended period of time, even after repeated cleanings.
The AEGIS Microbe Shield is available in Canada exclusively through Protect Technologies and its affiliated partners.

The AEGIS Microbe Shield allows surfaces to begin to defend themselves. It provides critical protection and reduction of exposure to dangerous microbes on frequently contacted surfaces in building environments. This protection is continuous and does not require frequent reapplication. With reductions in exposure come reductions of risk.

The AEGIS Microbe Shield is not a replacement for hand washing and good building hygiene. These are important tools in the ongoing effort to reduce risk of exposure. However, effective risk management requires more than one tool. Cleaning and disinfection simply has no lasting effect. Enduring protection is provide, however, with the AEGIS Microbe Shield. Albert Einstein once said that we should use tools and ideas to solve problems that are better than those that we used to create them. It is time for new ideas and time for the AEGIS Microbe Shield.

Reference Materials

Ayers, L. Fox, B., Jacobson, C., Smith, C., Kemper, R., White, W.C. Ohio State University Case Study - Aeromicrobial control in an extensively damaged hospital using a long lasting, surface active, silane antimicrobial. 18th An. Educ. Intl. Conf. of Assoc. Practitioners in Infection Control. May 7, 1991.

Kemper, R. A., White, W.C. and Gettings, R.L. 1990. Sustained aeromicrobiological reductions utilizing silane-modified quaternary amines applied to carpeting: Preliminary data from an observational study of commercial buildings. Dev. Ind. Microbiol. 31:237-244.

Malek, J.R. and Speier, J.L. 1982. Development of an organosilicone antimicrobial agent for the treatment of surfaces, Journal Of Coated Fabrics, Vol. 12, p. 38- 46

Speier, J.L. and Malek, J.R. 1982. Destruction of microorganisms by contact with solid surfaces. Journal of Colloid and Interface Science. 89 (1): 68-76.

Walters, P.A., Abbott, E.A. and Isquith, A.J. 1986. Algicidal activity of a surface bonded organosilicon quaternary ammonium chloride. Applied Microbiology. 25 (1): 253-256.

White, W.C., Bellfield, R., Ellis, J. and Vandendaele, P. 2007. Controlling the spread of nosocomial infections in hospital wards by the use of antimicrobials on textiles, facilities and devices. Presented at MEDTEX 07 – Fourth International Conference and Exhibition on Healthcare and Medical Textiles, Bolton, UK, July 16-18, 2007.

www.microbedefence.com
888.913.3150