Advantages of Thermal Surface Disinfection

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As anyone who works in the cleaning industry knows, clean and disinfected surfaces are crucial to preventing the spread of infectious diseases. Recent outbreaks of virulent microorganisms such as swine flu, MRSA, and *C. difficile* highlight this fact.

Generally speaking, professionals attempt to render high touch or frequently touched non-floor surfaces free from harmful levels of pathogens in commercial and medical settings in two basic ways:

- Clean (with detergent) and Dry
- Spray (with disinfectant or sanitizer) and Wipe

The two approaches listed above have been used for decades, but there is room for improvement.

Cleaning and drying a surface with a non-germicidal detergent is effective against some pathogens, but not all. Pathogens like Salmonella and toxigenic *E. coli* (gram-negative microorganisms) are generally adapted to wet environments, and so an initial removal is achieved when the surface is wiped and then drying helps to kill more germs – but this takes time and one can't count on drying to remove germs entirely. The "clean and dry" approach may actually do more harm than good when it comes to the kinds of pathogens that survive well on surfaces (gram-positive microorganisms like MRSA or "Strep"). The problem is that contaminants are not evenly distributed on surfaces. Some spots will be highly contaminated while others will be more or less free from pathogens. Non-germicidal detergents can spread pathogens from contaminated spots to clean spots, thereby increasing the infection risk posed by the surface as a whole.

The "spray and wipe" approach with liquid chemical disinfectants is most common, but compliance with disinfectant label instructions is poor. In most cases, surfaces are misted with the disinfectant product and then immediately wiped dry. The trouble is, laboratory testing of disinfectant products is *only* done with a liberal application of product at the contact time specified on the label, (usually ten minutes) so it is difficult to know whether the product is actually working at such short "real-life" contact periods. Additionally, in most commercial and medical settings, the wipe is used over and over again over multiple surfaces, making for accumulation of organic matter on the wipe that can interfere with the action of the disinfectant, or worse, the spreading of pathogens from surface to surface.

A new approach is thermal surface disinfection, where moist heat is delivered directly to contaminated surfaces by a commercial steam vapor system. Commercial steam vapor systems are designed to produce a targeted amount of high-quality, “saturated” steam. Saturated steam has relatively low moisture content, high temperature, and low particle size relative to steam produced by ordinary steam cleaners. The heat delivered to surfaces by the steam is extraordinarily germicidal. In fact, doctors and laboratories have relied on steam to disinfect critical equipment for decades. A unique and very attractive attribute of steam as a germicide is that it is chemical-free.

All commercial steam vapor systems remove soil well, but some deliver heat more effectively to environmental surfaces, and therefore do a better job of killing pathogens that may reside there. Well-designed systems deliver saturated steam through a cleaning head affixed with a textile component that traps the steam for maximum heat. Once the steam has left a cleaning head, it expands and cools rapidly. Therefore, the best tools for thermal disinfection hold the steam at the steam-surface interface.

One of the drawbacks of traditional disinfectants is the hindrance to efficacy brought about by porous surfaces such as fabric, wood, and clay or ceramics (e.g., tile). Microorganisms are very small, which means they may be protected from chemicals by microscopic irregularities on surfaces – even on surfaces that appear smooth to the naked eye. This presents a problem from an infection control perspective (think cutting board or hospital privacy curtain) since it leaves possible reservoirs of microorganisms untouched. Steam and heat energy naturally penetrates even the tiniest irregularities in the surface, yielding a more effective treatment.

When thermal energy is delivered efficiently to the surface, disinfection is rapid. Whereas liquid chemical disinfectants require, on average, 5 to 10 minutes to disinfect surfaces, thermal disinfection takes place in seconds. The following table summarizes the speed of surface disinfection demonstrated by a commercial steam vapor system (outfitted with triangular cleaning brush, towel, and TANCS unit) sold by Advanced Vapor Technologies (Edmonds, Washington):

Bacteria	**Contact Time**
MRSA (Methicillin-resistant *Staphylococcus aureus*)	5 Seconds
VRE (Vancomycin-resistant *Enterococcus faecalis*)	5 Seconds
Salmonella enterica	5 Seconds
E. coli	5 Seconds
Shigella flexneri	5 Seconds
Pseudomonas aeruginosa	5 Seconds
Staphylococcus aureus	5 Seconds
Listeria monocytogenes	7 Seconds
Clostridium difficile (endospores)	5 Seconds

Viruses

Norovirus (feline calicivirus)	7 Seconds
Canine parvovirus	7 Seconds
Avian Influenza (Bird Flu) H9N2	7 Seconds
Fungi	
Candida albicans	5 Seconds
Aspergillus niger	5 Seconds
Tricophyton mentagrophytes	7 Seconds

The speed of disinfection that is observed with a properly equipped commercial steam vapor system is likely due to the action of the heat on both the proteins that make up all microorganisms, as well as the fatty components of both bacteria and fungi. Proteins are the working and structural components of any cell. For viruses, proteins are the key structural feature that allows them to bind to host cells. When the temperature of microbial proteins is raised, they break down, or become “denatured.” Once a protein has been denatured, it must be replaced. When many proteins are denatured at once, the microorganism simply cannot overcome the damage and dies. In addition to protein damage, which affects all kinds of microorganisms, heat damages fatty components present in bacteria and fungi. Simply put, heat melts these fatty components, much like heat melts lard.

The activity of high temperature moist heat (e.g. steam vapor)on major functional components of a microorganism produces a great breadth of germicidal activity. One major problem with the traditional chemical approach to disinfection is the issue of efficacy gaps. Quaternary ammoniums (quats), for example, are highly effective against most bacteria but minimally effective against important non-enveloped viruses including norovirus and hepatitis A virus. Studies on commercial steam vapor systems have shown that rapid activity is seen across a broad range of pathogens, including enveloped and non-enveloped viruses, yeast, fungi, gram negative bacteria, and gram positive bacteria.

The quickness of the disinfection effect of thermal disinfection devices makes compliance with accepted cleaning protocols easier for cleaning staff, and therefore results in infection control benefits. Since pre-cleaning is less critical and the contact times necessary for disinfection are on the order of seconds, rather than minutes, staff compliance is naturally less of an issue for the commercial steam vapor system.

Additionally, commercial steam vapor systems afford a key advantage: The contact surface of the cleaning tool remains very hot, so the potential for cross-contamination from surface-to-surface or room-to-room is greatly reduced. This is in sharp contrast to the traditional “spray and wipe” approach, which recent studies suggest can actually spread live pathogens from one surface to the next, especially if the disinfectant becomes overused or is inadvertently inactivated.

Since heat dissipates quickly from the surface once it has been treated with steam, no residual is left behind. This is in sharp contrast to virtually any "spray and wipe" approach, where residual chemical is left on disinfected surfaces. A comparison can be drawn between surface disinfection and drinking water disinfection: Both ozone and chlorine are effective disinfectants for water. Ozone is preferable from a health standpoint, since it does not leave a residual in the treated water. Chlorine is used, however, because regrowth is an issue and a residual amount of chlorine helps to keep regrowth in check. On regular dry surfaces, growth of microorganisms is not a concern, and therefore a chemical residual may not be desirable. In this respect, steam may confer certain chemical toxicity advantages for surface disinfection.

A particularly well-validated thermal disinfection device is the MondoVap 2400 by Advanced Vapor Technologies (Edmonds, Washington). The device has been tested by three separate, independent laboratories, all of which operate to Good Laboratory Practice (GLP) standards. A realistic test system was designed for all studies (many of which were done entirely in duplicate). High initial microbial concentrations were used, dried onto a mix of porous and non-porous hard surfaces. Study results show that the system (Mondovap 2400 with TANCS®; fitted with triangular cleaning attachment) rapidly kills viruses, fungi, and antibiotic-resistant bacteria, providing a sanitizing benefit within two seconds of surface contact and disinfecting surfaces within 5 seconds (Tanner, 2009). Original laboratory test reports are publicly available through the manufacturer's Web site.

In conclusion, thermal surface disinfection is fundamentally different from the traditional "spray and wipe" approach to cleaning, usually involving liquid chemical disinfectants. Advantages are evident with respect to reduced cross-contamination, increased compliance with use instructions, speed of disinfection, and breadth of microorganisms killed. Chemical residuals are not left on the surface after thermal disinfection, which may be desirable from a toxicity standpoint. In light of the advantages listed here, thermal disinfection may be worth considering for your institution.

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References:

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