APRIL 2016 | US$39

ICT INFECTION CONTROL TODAY

Special Report

Disinfectants and Surface Compatibility

By Kelly M. Pyrek

Efficacy of hospital-grade cleaners and disinfectants is one of the most widely scrutinized aspects of surface disinfection, yet this factor could be undermined by the lesser-known obstacle of materials compatibility — how cleaning and disinfection chemistries interact with the materials from which healthcare equipment and surfaces are manufactured. This report explores the issue of how the chemical disinfectants used for cleaning and surface disinfection in the healthcare setting affect the surface materials used in common healthcare equipment and the built environment.

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Disinfectants and Surface Compatibility

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Efficacy of hospital-grade cleaners and disinfectants is one of the most widely scrutinized aspects of surface disinfection, yet this factor could be undermined by the lesser-known obstacle of materials compatibility — how cleaning and disinfection chemistries interact with the materials from which healthcare equipment and surfaces are manufactured.

For example, in its Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008, the Centers for Disease Control and Prevention (CDC) outlines the advantages and disadvantages of chemical agents used as chemical sterilants or as high-level disinfectants, and addresses the fact that there can be "materials compatibility concerns (lead, brass, copper, zinc), both cosmetic and functional" with chemicals such as peracetic acid and hydrogen peroxide.

We must remember that killing germs is often the foremost goal of the disinfectant manufacturer, and that formulating a disinfectant is a complex process because task for chemical engineers who may or may not be thinking about creating a balance between efficacy and safety, considering the performance criteria demanded by the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA). It is up to the end user, the hospital staff, to consider any compromises that are acceptable or not in terms of outcomes and jeopardy to patients and healthcare personnel. All disinfectants have contraindications for certain materials, and so fact-finding and education during the product evaluation and purchasing process is key. Garrett (2016) notes that a germicide's compatibility, efficacy and safety must be balanced, and the trade-offs understood.

The healthcare setting is one of the most complex built environments in terms of the mix of hard and soft surfaces, including stainless steel, plastics, polyesters, acrylics, vinyls, tile, substrates, laminate and others. Lybert and Hicks (2015) have shown that with three feet of the patient in the typical hospital room, there can be as many as 15 different surfaces, of varying materials and textures, and all can serve as reservoirs of pathogenic organisms that can be transferred to patients and healthcare workers — studies in the literature have demonstrated that bacteria and viruses survive on surfaces for days, weeks, and even months. Adding to the cleaning and disinfection challenges are the assemblies, the areas where different materials meet and the seams that can absorb moisture and serve as breeding grounds for microbes and biofilms.

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There is a considerable lack of attention on the part of healthcare institutions when it comes to the kinds of materials that are used in the built environment of the hospital, according to Linda Lybert, president of Healthcare Surface Consulting, who regularly addresses organizations on the perils of surface cleaning and disinfection, surface material selection and compatibility challenges, and the problems associated with not considering all aspects of this trifecta that involves clinical, fiscal and operational stakeholders.

"A general lack of awareness continues to persist, as people are not asking questions about the compatibility of chemicals that are being used on healthcare surfaces," Lybert says. "Some manufacturers, if asked, will provide a list of chemicals that they have tested on their surface materials. For example, a company will have tested their one wall panel materials against a chemical such as peracetic acid, so they will know that it will react on the surface material and cause permanent damage. And when they say permanent damage, they don't explain what that means — it may be discoloration, or it could actually be where the surface material fibers break down and then little cracks and fissures develop in the surface material that allow a safe harbor for microbes. There are even some acids that react to stainless steel — so for instance if you use a brushed stainless steel and it the peracetic acid gets on it for any amount of time, it will create a much deeper groove which is usually missed in the cleaning process."

As Ferriera (2016) notes, "It's not just one material or surface; in the healthcare environment there is vinyl, upholstery, Formica, metals and plastics, so it's all-encompassing… We have a lot of devices and equipment in healthcare facilities and finding the appropriate cleaners and disinfectants is challenging because we must mitigate pathogenic organisms and still provide a safe environment."

Ferriera and Garrett (2016) explain that material incompatibility is the failure of a material when exposed to certain types of environmental factors, and is caused by poorly designed part(s); poorly manufactured part(s); selection of incorrect material for application; and incompatibility with contact materials such as cleaners, disinfectants and sanitizers. As Ferriera (2016) observes, "How a product is designed is as important as the materials used. We must ensure that the materials are appropriate for the healthcare environment, and we must drive education around the kinds of products we use, the appropriate tools that are necessary, and work with manufacturers of devices, equipment, surface materials and chemicals."

Lybert notes, "Surface selection and evaluation are predominately based on the design criteria established before any construction or renovation project. How it looks and where it is located is based on creating a homelike atmosphere and a healing environment. While this is important, if you can't actually clean the surfaces and there is a good possibility of contracting a HAI during a hospital stay a healing environment has not been

created. The selection of surfaces is complicated. The goal is to select a combination of surfaces that can be effectively cleaned and disinfected, leaving little room for human error. Unfortunately, right now the majority of surfaces being used in healthcare are difficult if not impossible to clean effectively." She adds, "It is critical that information be collected to address the ability to clean and disinfect the surfaces being selected. Equally important is making sure the ability to clean and disinfect surfaces follows recommended guidelines and infection prevention requirements. It is too common that facility staff learn that the surface materials chosen cannot be cleaned effectively using disinfection products without serious surface damage. Unseen microbial reservoirs create unnecessary risk to patients, healthcare workers and the general public. It also becomes costly to the facility, as products need to be replaced or repaired."

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"Environmental services personnel are not going to check compatibility between chemicals and surface materials, and this is the crux of the issue," Lybert says. "They don't do it because they don't know what questions to ask and are typically left out of the surfaces discussion during the selection process. So we pretty much have to live with the surfaces we have in our healthcare environment on a day-to-day basis. What has to happen is boosting the awareness of surfaces we are using in our hospitals and educating key decision makers about how the surfaces are reacting to the products with which we use to clean them. One of my frustrations is that people are not accepting the fact that surfaces are contaminated, bacterial reservoirs exist, and surface materials play a significant role in this. They say, 'We will just clean better.' Unfortunately, cleaning better doesn't happen and in many cases is impossible due to the unseen damage and microbial reservoirs that exist; lack of knowledge and a clear understanding of the problem very much exists and persists." Lybert recalls being part of a conversation with several infection preventionists who were trying to cope with a Clostridium difficile problem in their emergency department who said that they were not worried about surface materials, they were just concerned about disinfectants. "This facility had been fined for high infection rates, and it was yet another glaring example of a lack of awareness about surface materials, disinfectants and the role they both play in HAI transmission and prevention."

Lybert points to expert Jon Otter, PhD, of Imperial College Healthcare NHS Trust, who recently conducted a poll asking respondents what they thought was the most important reservoir associated with healthcare-associated infections (HAIs). "About 90 percent of respondents said contaminated hands, while others said it depends on the pathogen and the situation, and maybe 5 percent said contaminated surfaces. In talking to facilities, I think that's about where it is, and that's alarming."

Lybert urges healthcare institutions to consider what materials exist in the facility, what chemistries are being used to clean and disinfect equipment and surfaces, and how these two interact. "It is not enough to learn every physical characteristic of a given surface and surface material or to become an expert in the latest disinfection agents and protocols," she says. "This data must be combined with an understanding of microbiology, the physical environment and insight into human behavior."

Lybert points to several key aspects of surface materials as they relate to the environmental hygiene process:

- **Materials and textiles:** Hospital personnel should be aware of textured surface materials, such as brushed stainless steel, pebble texture acrylic wall surfaces, and textiles used for soft surfaces, such as privacy or shower curtains. "What will it take to clean these surfaces? How often do they need to be cleaned to reduce bioburden and prevent cross-contamination?" she asks.
- **Surface assemblies:** Lybert explains that different materials and textiles are often combined into a single product, making the product difficult or even impossible to clean and disinfect thoroughly. As a result, microbial reservoirs are created at material connection points and on textured surfaces.

As Lybert notes, "When we look closely at surfaces surrounding the patient, we see similar combinations and connections between different materials. Seams, baton strips and connects between surfaces create microbial reservoirs that can be completely avoided when this problem is understood."

- **Location:** Where surfaces are located matters. Different departments within the hospital require more focus on the types of surfaces being used. As Lybert notes, "Faced with a need to turn a room over quickly often means that healthcare workers with a primary responsibility for patient care must also clean, disinfect and turnover the room. It is entirely possible to use surfaces that can be easily and effectively disinfected."

One of the most significant challenges for environmental services personnel and infection preventionists is hearing from disinfectant manufacturers that anything can be used to clean all surfaces. "Further questioning often begins to reveal a lack of understanding of infection prevention protocol and cleaning and disinfection products," Lybert says. "Surface manufacturers don't know what they don't know, particularly when it comes to infection control strategies, processes and products. Multiple products may be used, some of which may cause serious damage to surfaces. Many microbial reservoirs are impossible to see. When a room is tested for effective disinfection, testing will provide one result immediately following disinfection, but will often show that microbial counts have rebounded significantly two hours after cleaning."

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Lybert emphasizes, "Environmental services personnel are responsible for cleaning the surfaces, and to be able to do that they really need to understand what types of surfaces they are the surfaces and how they need to be cleaned. Not that they are going to change what they are cleaning with, but hopefully they will begin to realize that a countertop three feet away from the patient's bed that is laminate and has seams and probably is very moist under the surface and will be embedded with pathogens. The cleaning product being used is breaking down the fibers and creating fissures. Unless that issue is addressed, cleaning and disinfection efforts will be undermined. We are unwittingly destroying surfaces so contamination will

persist; we aren't seeing a significant decrease in infection rates even though we are trying to do a better job of cleaning and it's because we are not looking at the surfaces too."

Sometimes it takes extreme action to prove a point. Lybert says an important study a few years ago demonstrated that biofilms, consisting of bacteria embedded in exopolymeric substances (EPS), are difficult to remove due to their increased resistance to detergents and disinfectants, and periodically release free-swimming planktonic bacteria back into the environment which may act as an infection source.

"The Vickery study involved destructive research, meaning that following terminal cleaning, they cut pieces of surfaces out of the ICU and took them to the lab," Lybert says. "They used the microscopy to look at these surface samples and were blown away by what remained in and on those surfaces."

Vickery, et al. (2012) essentially aseptically removed equipment and furnishings from an intensive care unit (ICU) and subjected them to culture and scanning electron microscopy. Biofilm was demonstrated visually on the sterile supply bucket, the opaque plastic door, the venetian blind cord and the sink rubber, whereas EPS alone was seen on the curtain. Viable bacteria were grown from three samples, including MRSA from the venetian blind cord and the curtain.

Lybert says manufacturers must provide information on surface compatibility and disinfectants to end users, and these end users must heed existing manufacturer warnings. Says Lybert, "During a recent presentation, members of the audience were surprised to learn that so many products actually have warnings about the use of chemicals contained in commonly used disinfectant products. It is not unusual to find that a manufacturer has tested specific chemicals on their product, but has not tested disinfection products. Test results can vary when an actual disinfectant product is tested, since it may be composed of multiple active and inactive chemicals."

Manufacturer warnings vary in complexity and comprehensiveness. Lybert and Hicks (2015) provide a few examples of such warnings:

Laminate:

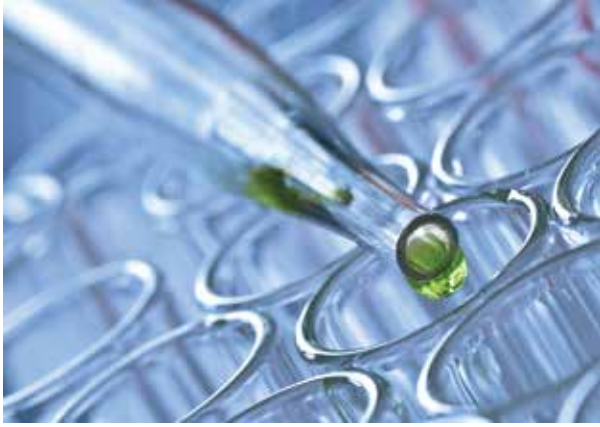
- "Prolonged exposure of the laminate surface with bleach will cause discoloration. Always rinse laminate surfaces after cleaning. If a small amount of cleaning solution remains on the surface, moisture can reactivate it and result in permanently etched scars."
- "Acidic or abrasive cleaners can damage laminate surfaces; do not use them."
- "Steel wool and other abrasive pads will damage laminate. Don't use them for cleaning and don't store steel wool pads on your countertop; the metal can rust and leave stains."

Stainless steel:

- "Avoid prolonged contact with chlorides (bleaches, salts), bromides (sanitizing agents), thiocyanates (pesticides, photography chemicals, and some foods), and iodides on stainless steel equipment, especially if acid conditions exist."

Solid surface:

- "Avoid harsh chemical such as drain cleaners and paint removers. Bleach and water are suggested cleaners for sinks and countertops."



Says Lybert, "It truly is a science, and manufacturers of both the surface materials and the disinfectants must understand that each can have an effect on the other. We can't expect the healthcare facility to use 20 or 30 different products and educate them about which product to use on which surface, but we can ask manufacturers which of these chemicals have an effect on the surfaces, and then make the decision on which materials to use in the healthcare environment. We know we have to clean the facility but it's fascinating that no one is asking for the manufacturer warnings around cleaning and disinfecting and the products and chemicals being used; whereas the manufacturers are overlooking the need to test and evaluate these chemicals. We need more research, and we need to be much more active about evaluating the impact that cleaning and disinfecting is having on materials, as well as their effectiveness. Many years ago, someone said to me, 'Do you know how many surfaces exist in the healthcare facility? If we talk about it, we have to do something about it and where would we even start to do that?' So it has been a head-in-the-sand mentality. People don't want to make it an issue, and that's a serious problem."

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Ferriera (2016) notes that "Industry is being asked to mitigate more pathogens than ever before. So we need more thorough, standardized testing to ensure that surface and equipment materials are keeping up with the evolving disinfectant chemistries. Incorporating standardization in testing upfront would be a significant culture change for manufacturers. Right now the lack of standardization in materials and chemistries is an imperative issue, and so we need to be working at the forefront to generate awareness and drive change."

Greater awareness involves a better understanding of the factors that impact a surface material's product life, including what these materials are; what cleaning and disinfection products are being used and how the equipment or surface has been designed as its function; and chemical exposure that impacts the life of the equipment or surface. Ferriera and Garrett (2016) say that the top indicators of material incompatibility are environmental stress cracking (ESC); color/visual change; and texture change. These indicators can also include chemical attack, thermal degradation, notched static rupture, and dynamic fatigue.

Ferriera (2016) emphasizes that materials failures are driving the need for standardization awareness and efforts, and that industry and end users must create a coalition of sorts to drive awareness of the issue of compatibility and identify long-term solutions. But there are barriers. As Ferriera (2016) notes, "Proprietary information makes getting information from manufacturers more challenging. So we need to improve the quality and amount of technical information available." Ferriera (2016) points to the lack of standardized testing, describing an "apples-to-oranges" approach currently because different disinfectant products have different carrier systems and they are tested in different ways,

thus exacerbating the problem. Additionally, ASTM testing methods are not applicable to everything, and there is no correlation between methods. As Ferriera (2016) notes, " There is no standard testing method for all surface disinfectants, and success criteria is non-existent, therefore allowing plastic manufacturers, for example, to set their own criteria."

To help address the situation, Ferriera (2016) says standardization must be embraced, healthcare professionals must be educated about the issue, and that the "best outcomes are when medical device manufacturers, plastic suppliers and disinfectant companies collaborate and work toward standardization." There must also be a standardization of plastics used in medical devices that are known to provide extended shelf-life when in contact with intermediate-level disinfectants. Additionally, healthcare personnel must possess and follow device manufacturer cleaning instructions and use approved disinfectants. Healthcare professionals are encouraged to ask medical device and disinfectant reps questions regarding material compatibility to ensure their investment is properly maintained. As Garrett (2016) adds, "Telling people to clean and disinfect equipment and surfaces and then having equipment degradation occur sets us up for failure."

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Garrett (2016) emphasizes that improvement can only come when standardization in testing is enforced and there is better government regulation. Currently, surface material manufacturers are not required to test their products against disinfectants, but Garrett (2016) explains that, "We need to make sure the FDA appreciates the role it plays, and require manufacturers to specify in their instructions for use (IFU) what chemicals can and should not be used. We are waiting for the FDA to take a formal stance on this issue, and I am optimistic about the future." He adds, "New products must go through an evaluation process, but legacy products do not. The challenge is for manufacturing partners to prove how chemicals and materials interact, and end users have a right to ask about this."

From a third-party perspective, there are laboratories in the marketplace currently that conduct tests for compatibility using soak tests and customized mechanical abrasion tests. As Microchem Laboratory explains, "When a disinfectant is incompatible with the substrate to which it is applied, outcomes range from minor aesthetic modifications to loss of surface or textile functionality. In some cases, damage may appear rapidly. In other instances, damage may manifest over time. In order to determine use instructions and mitigate the risk that a disinfectant will damage surfaces, manufacturers engage laboratories to conduct materials compatibility tests. Materials compatibility tests are required by FDA for disinfectants which are used to disinfect critical medical devices. The tests are not mandated by EPA for ordinary disinfectants, but are advisable nonetheless. Few standardized procedures for materials compatibility testing have been developed, so testing is most often customized based on the anticipated use of the disinfectant. Relevant factors include use type (immersion, spray, or wipe), and exposure or dwell time. Sophisticated companies also account for the effect of product evaporation, since the process of evaporation can temporarily concentrate the active ingredient or cause it to precipitate."

The most common type of materials compatibility test is a simple soak test, where a broad array of test materials are soaked in the disinfectant for a period of time equivalent to the dwell time of the product multiplied by the number of desired use cycles. The end result of materials compatibility testing is a concise data summary defining the total number of product exposures that can be considered "safe" for each material that was tested.

The second most common test is a mechanical abrasion test. This is most applicable do disinfectant towelettes. The towelettes are loaded onto a standardized abrasion-testing machine, saturated with disinfectant, then scrubbed repeatedly over the surface at a set abrasion pressure and speed.

Manufacturers and testing laboratories sometimes work together to address the issue of surface compatibility. As Microchem Laboratory notes, "The majority of disinfectants are compatible with most materials, but when incompatibility is evident, the damage is often obvious and companies benefit. For instance, a recent study at Microchem found that two different disinfectants damaged the delicate screen of a particular electronic device. By comparing ingredients in the damaging formulations and contrasting with screen-compatible formulations, the product formulator was able to identify the responsible ingredient — valuable information for any company in the era of electronics." ■

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