Decontamination of Sensitive Equipment
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Not all chlorine dioxides are created equally. The use of pure chlorine dioxide gas successfully decontaminated an imaging laboratory — with the equipment in place.

In November 2008, an imaging laboratory was decontaminated using chlorine dioxide. The laboratory was filled with analytical and imaging equipment which is regularly used. After the decontamination, the analytical and imaging equipment in the laboratory worked just like before.

This was just another example of chlorine dioxide gas being used to decontaminate an area containing sensitive equipment. However, there still exists a stigma amongst many in the research field that chlorine dioxide is inherently corrosive. This impression is based on experience and fact, but it is still not necessarily true.Many people are familiar with some of the liquid chlorine dioxides on the market and have seen corrosion after using them, which is how their perceptions came about. Not all chlorine dioxides are created equally though, with pure chlorine dioxide much gentler than the corrosive liquid chlorine dioxide solutions which have been on the market for years. The use of pure chlorine dioxide gas is what made decontaminating the imaging laboratory a success.

Background Information

Chlorine dioxide is an oxidizer, as is hydrogen peroxide, ozone, and oxygen among many other agents. Oxidation/reduction potential is a measure of the tendency of a chemical species to gain electrons and oxidize other chemical species. A higher oxidation/reduction potential means that the species is more likely to gain electrons and is a stronger oxidizer. This gives a numerical value as to how corrosive the agent is.

Chlorine dioxide has an oxidation/reduction potential of 0.95V, which is lower than another commonly known decontaminating agent, hydrogen peroxide, as well as the lesser used agent, ozone. The reason that chlorine dioxide has a worse reputation concerning corrosion is due to byproducts created in the method of generation of some common liquid chlorine dioxide solutions that have been used for many years.

Generation Method

The generation method of chlorine dioxide is where the difference in corrosiveness can be found. There are many different methods of generation for chlorine dioxide. Many of the liquid methods are created by mixing an acid and a base which then forms an acidified chlorine dioxide solution. A common generation method for liquid chlorine dioxide is:

mixture of base + water + activator = acidified sodium chlorite + chlorous acid + chlorine dioxide

The production of two acidic components, acidified sodium chlorite and chlorous acid, is where the corrosive properties come from. The pH of these solutions is typically around 3. This liquid is then fogged or sprayed throughout the room, and onto sensitive materials. Some institutions perform a follow up water rinse upon completion of the decontamination when using liquid chlorine dioxide. This follow up rinse does remove leftover corrosive materials from easy to reach places. This lessens the impact that the corrosive solution would have as it is removed from staying in contact with surfaces for a long period of time. However, it does not eliminate the risk of corrosion completely, as the acidic solution did contact materials during the decontamination itself. It also does not remove any acidic solution from unreachable areas, such as behind grills and inside of electronics.

Pure chlorine dioxide, which can be generated in the gaseous phase, does not have the same effect on materials. Water injected with pure chlorine dioxide gas still has a pH of 7, meaning that the solution is neutral. A method of generating pure chlorine dioxide gas is below:

reagent (gas) + sodium chlorite (solid) = chlorine dioxide (gas) + salt (solid)

The solid salt product is retained within the system and not introduced into the space being decontaminated. By not introducing acidic byproducts along with the chlorine dioxide gas, this leaves just the pure chlorine dioxide gas contacting the contents of the space. Chlorine dioxide gas does not leave a residue, so there is no worry of residual contact causing a negative effect on materials and components within the area being decontaminated.With a comparatively low oxidation/reduction potential, using chlorine dioxide gas generated in this fashion is a safe and reliable method of decontamination when concerned with material compatibility.

Decontamination of an Imaging Laboratory

The imaging laboratory, used for imaging and analytical procedures, was considered to be potentially contaminated, and decontamination was called for to ensure the cleanliness of the laboratory for future use. The facility was also using this decontamination as a trial to see the effects of chlorine dioxide gas on their room and its contents. The laboratory measured 16' x 20' (2560 ft^3) and contained various electronics and instruments. Some of the equipment within the laboratory included laptop and desktop computers, VisualSonics ultrasound equipment, a Xenogen gas anesthesia system, a Harvard rodent ventilator, scales, a NuAire Biological Safety Cabinet, and a Xenogen IVIS Imaging System. This equipment was regularly used and in good working order prior to decontamination. The plan was to test the equipment after decontamination to determine if the chlorine dioxide gas had any deleterious effects. The room itself would also be examined upon completion of the decontamination to see if any corrosion or degradation occurred.

The entire decontamination took approximately 3.5 hours, from when the room was sealed until the time when the room was reentered safely. The decontamination itself was comprised of five steps. After the room is sealed, the humidity level within the room was raised to between 60-75% Rh in the pre-condition step. Next was the conditioning step, where the room was held at the correct humidity level for a prescribed amount of time. This humidity level is necessary in all spore reduction, as it softens the spore walls so that the decontaminating agent can penetrate them. Following the conditioning step was the charge step, where the chlorine dioxide gas was injected into the room. Upon reaching the correct concentration, 1 mg/L of chlorine dioxide gas, the exposure step began, where the correct concentration level was maintained for a prescribed amount of time. The exposure time was two hours for this concentration level. After that step, the gas was removed from the room, and the cycle was complete.

As chlorine dioxide gas leaves no residue, no clean up was necessary afterwards, leaving the room and its instruments ready to be entered and used directly upon completion of the gas decontamination.

To provide confirmation of a successful decontamination, 106 bacillus atropheus biological indicators were placed in various places inside of the room. The biological indicators were placed underneath and behind various pieces of equipment within the room, and not out in the open to confirm chlorine dioxide gas's reach and ability to penetrate small openings.

Results

Every biological indicator placed within the laboratory was killed, showing no growth when incubated for seven days. A positive control biological indicator kept outside of the laboratory was incubated as well, and did show growth after 24 hours. This proved the efficacy and success of the chlorine dioxide gas decontamination.

Upon completion of the decontamination, the facility manager performed a visual examination of the room and of the instrumentation and components within the room. There was no damage or degradation to any of the components in the laboratory. There were no residues found within the room, and no corrosion seen on any surfaces. The imaging and analytic equipment within the room was then used and tested shortly after the decontamination was completed. All equipment performed and functioned as it had prior to the decontamination.

Conclusion

The imaging laboratory decontamination illustrates the truth about the material compatibility of chlorine dioxide gas. It has been used on many occasions to decontaminate sensitive equipment, with the contents of the imaging laboratory a small sample of its range. Only because of people's experience using acidic liquid chlorine dioxide solutions does chlorine dioxide have a negative image in the research field. Without an acidic component, gaseous chlorine dioxide is scientifically the best method for decontamination when considering material compatibility.

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