Not Everyone Likes Bubbles!

Trials and Tribulations of Fumigating a New Life Sciences Facility Using Hydrogen Peroxide

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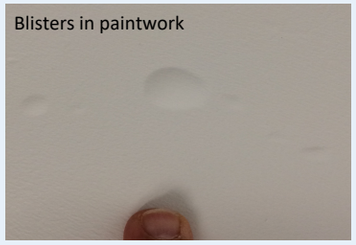
Introduction

Following the deep clean and fumigation of our new biofacility, numerous patches of bubbled / blistered paintwork were observed throughout the building. The paint had been selected as it was known to be used in other facilities regularly fumigated using hydrogen peroxide (H2O2) in vapour form, but upon investigation we learnt that the formulation of the paint had recently changed to remove volatile organic compounds (VOCs) and even more recently the data sheet had been revised listing only 3 compatible H2O2 fumigation systems – the system we had used was not on the list.



The damaged paintwork was repaired and after a period in excess of the recommended curing time the rooms were re-fumigated using a different system; one that was listed by the paint manufacturers.
Although there was less bubbling to the paintwork a small number of patches occurred – this was particularly problematic within the CL3 area which would need regular routine fumigation.

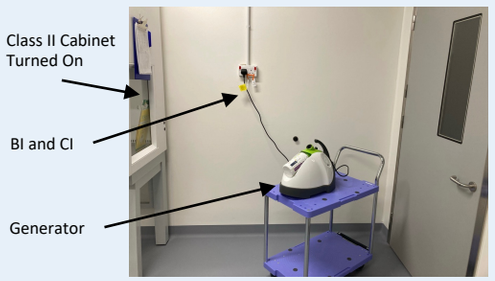
Meetings were held to discuss the issue – do we repaint the entire CL3 with a new paint product or install sheet wall covering, both of which would involve the long-term closure of the facility and complete removal of the existing paint - or do we look at alternative fumigation methods?

We decided on the latter, which as it turned out was fortunate as COVID 19 was just around the corner and our CL3 facility would be required!

We approached one of the other two companies recommended by the paint manufacturer and after a successful test run the University was offered a generator, on loan, to carry out further trials within the CL3 area. As well as providing the loan equipment the representative company provided all consumables and continual support and assistance during what turned out to be a lengthy trial period.

The generator heats, ionises and then disperses the fumigant in a fine dry fog into the room at 80m/sec. The generator we used has a maximum capacity of 1 litre and is able to disinfect rooms from 10 to 1000m3.

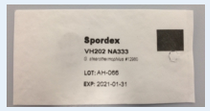
The Bio-disinfectant used contains 12% hydrogen peroxide and silver, some other systems use 35% hydrogen peroxide.



Typical Room Set-Up

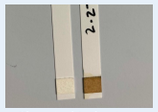
Method and Results

The volume of the room to be fumigated is calculated and this figure is multiplied by the amount of fumigant per m3 required; generally 3ml per m3. The generator is then placed in one corner of the room with the dispersal nozzle (venturi) facing upwards towards the opposite diagonal corner, and the fumigant level set. The room HVAC is turned off and the doors sealed with acrylic door covers and tape. The Class II cabinets and room based IVC AHUs (if present) are operational. All caging containing nesting and bedding material is removed.



Biological Indicator

Chemical Indicator Colour Change Guide



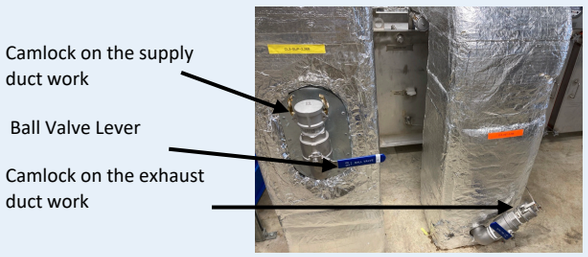
Chemical Indicators, Before & After Fumigation

During each trial we used 10 Biological Indicators (BIs) which use a stainless-steel carrier inoculated with an E6 (6-log) population of *Geobacillus stearothermophilus* spores; the inoculated carrier is placed in a Tyvek®*1* envelope). These 10 BIs in association with 10 Chemical Indicators (CIs) were placed throughout the room – at different heights and in challenging locations e.g., within cupboards and under benchtops. For a cycle to be deemed successful the University required a 6-log deactivation of all BIs and a colour change to the CI indicating exposure of >50ppm for at least 1 hour. A control BI was used in conjunction with every test; all BIs were issued for independent culturing.

As to be expected when first using a product, and using it in a new application, deactivation of all BIs was not achieved during the first few trials, but after removing the room circulation fan (the tests indicated this fumigant was most effective with a dwell period with limited air movement), increasing the amount of fumigant used from 3ml to 5ml per m3, and running two cycles consecutively, 3 hours apart (each cycle lasted circa 30 mins), we were able to develop repeated deactivation of all BIs in the room and thus provide us with validated cycles for both the holding and procedure rooms within the CL3 facility and almost as importantly – with no bubbling of the paintwork.

As previously mentioned, the generator is room-based – fine for decontaminating the actual room but we also needed to decontaminate the exhaust ductwork.

Camlocks had been incorporated into the HVAC ductwork design to allow for plant-room based fumigation of the holding and procedure rooms. To facilitate the movement of fumigant into the exhaust duct whilst using a room-based generator, we used a slightly modified isolator fan to draw fumigated room air into the exhaust duct and back into the room via the supply duct using these camlocks. A BI and CI were placed within the fan unit to demonstrate whether the fumigant had travelled along the entire length of ductwork.



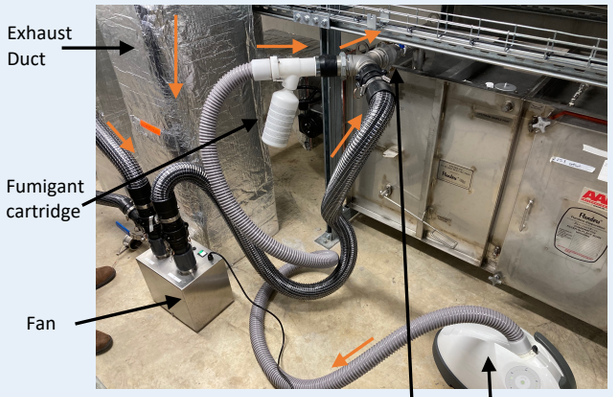
This method worked well for short lengths of ducting but not so for longer lengths of >7m.

We were uncertain as to the cause of the poor results with the longer lengths of ductwork, the CIs indicated that the fumigant was progressing along the ductwork but the BIs were not being deactivated. Possible reasons considered were that the twists and turns in the long lengths of ductwork were causing airflow issues or that warmed, fumigant laden air was condensing upon contact with the cool stainless-steel ductwork. Whatever the issue was we had a problem!

We decided that to get sufficient fumigant at the right concentration into the exhaust ductwork a new approach was required - we needed to introduce the fumigant directly into ducting.

Further discussions were held with the generator representative, and they agreed to supply a second generator and suggested an alternative dispensing nozzle which when used with a 3-way connection attached to the camlock on the HEPA housing meant that we could introduce fumigant straight into the ductwork nearest to the HEPA filter. The return fan hose was connected to a camlock at the room end of the ductwork so that a semi-closed loop was formed with the fumigant being drawn through the duct.

For the first cycles we decided to fumigate the duct and room at the same time so that the entire length of exhaust duct, from inside the room up to the face of the HEPA Filter, was decontaminated together.



For this initial trial we used a T connection but unfortunately noted fluid leaking at the joint during the cycle. As well as the joint not being airtight we surmised that the angle the fumigated air was entering the air flow was causing the fumigant to condense. For the second trial we used a Y connection which allowed the fumigant and air from the fan to mix whilst moving in the same direction. No leakage was noted during the cycle (and no condensate was found to be present in the hoses).

However, although the results from the second trial were good, we believed them to be inconclusive. The CI in the fan had a good colour change and the BI was deactivated but the positioning of the fan meant that we could not definitely state that the changes to the BI and CI was due to the fumigant that had travelled along the duct rather than the fumigant coming directly from the room. Another change of approach was required, for this we fumigated the ductwork independently of the room fumigation. The generator was set up as before, but the room was not fumigated at the same time, this meant that any CI colour change and deactivation of the BI was due solely to fumigant that had been drawn through the entire length of duct.

Due to the design of the ductwork, complete separation of the exhaust duct and the room was not possible. We therefore had to accept that there would be some leakage of fumigant into the room and that some 'fresh' room air would be drawn into the duct, to counteract this we increased the amount of fumigant to 7.5ml per m3. It was decided that each cycle would consist of a 4 minute 30 second injection of fumigant on the hour for four hours followed by an overnight (>12 hour) dwell period. (It is acknowledged that his amount of fumigant is probably excessive and the cycle will be refined in due course). A second full cycle with fresh CI and BI was repeated the following day and the BIs sent for culturing. The colour change to the CIs was very good and the results received 6 days later showed no growth to the BIs – we had now demonstrated that the room and exhaust ductwork up to the HEPA filter could be successfully decontaminated.

Conclusion

Having had over 20 years experience of using various H2O2 dispensing systems I must admit to being rather sceptical of the ionised hydrogen peroxide system and the results that would be achieved BUT...

Firstly, the equipment was very easy to use:

- Simply calculate the volume of the room and multiply this by the amount per m3 to be used (e.g. 3ml per m3).
- Then, set the dial to the resulting amount. Turn off the room ventilation, seal the room and press start on the remote control.
- It is also extremely portable, being light and about the same size as a microwave oven.

Secondly and most importantly we obtained repeatable results with 100% deactivation of all spore strips (BIs) placed in the room and with **NO BUBBLES TO THE PAINTWORK!**

Future Plans

Following the successful trials within the CL3 facility we have looked at other applications for the ionised H2O2 generator. Initially the method of delivery appeared to restrict its use to room fumigation however following the addition of the recirculation fan additional uses look possible including fumigation of Class II Safety Cabinets and Isolators where connections for a closed loop H2O2 system had been fitted.

Discussion

Fumigation using H2O2 in vapour form is now one of the primary methods of decontamination within the life science field. Over the past few years a number of new methods to dispense hydrogen peroxide have been developed but uptake of these new technologies appears to be slow within the UK life sciences industry whereas they are widely used by our contemporaries in Europe and America and are also routinely used in other UK sectors such as Public Health.

However, after our experiences with reformulated paint it is maybe time to give these new approaches a chance within our industry, not only have we found that they work – they are cheaper too!

Acknowledgements

For many reasons, not least the Coronavirus Pandemic, the development of validated cycles for use within our CL3 facility has been a lengthy process and we would like to thank the following companies for their time, support, encouragement, patience and above all their generosity.

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NKP Ltd

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