VOLUME 10
No.3

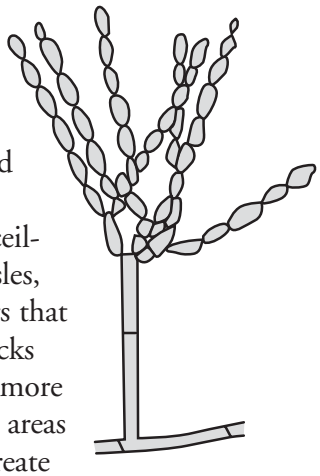
Archival Products NEWS

Chlorine Dioxide: A Treatment for Mold in Libraries

by Kristina L. Southwell

MOLD HAS BEEN RECOGNIZED as a serious threat to the safety and longevity of library materials for many years. Its ability to weaken, discolor, and destroy books and other paper items is well known. Although most librarians and archivists are aware of mold's negative effects on collections, many do not have first hand experience in dealing with an active mold bloom until mold is unexpectedly discovered in their library's stacks. In 1991, employees at the University of Oklahoma Libraries received a quick course in mold abatement, when mold was found growing in a book stack area.[1]

OU's Bizzell Memorial Library is made up of three joined structures erected in 1932, 1958, and 1982. The mold bloom, initiated by a combination of roof leaks and malfunctioning air handling systems, occurred in the original 1932 portion of the building. The book stacks in this area are commonly referred to as "the decks", and they house older, Dewey-classified books on steel shelving. Low ceilings, narrow aisles, and heavy doors that close off the decks from the other more frequently used areas of the library create an environment that often has less than adequate airflow. The lack of good air circulation combined with the accidental added moisture and heat produced a climate well-suited for mold growth.



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As with any situation in which a mold bloom occurs, attention was first given to stabilizing the temperature and humidity by repairing the roof leaks and the air handling system. When these factors were brought under control, library workers began using a thymol solution to wipe mold from the books. When concerns

arose about possible carcinogenic effects of thymol, the treatment was halted and a microbiologist was consulted for advice on an alternative chemical treatment. Library administrators chose chlorine dioxide for its effectiveness as a sporicide, and for its safety level for library employees and patrons.

Chlorine dioxide is commonly used as a biocidal agent in water treatment applications, paper manufacturing, and many branches of the food processing industry.[2] It can be used in both aqueous and gaseous forms, and has recently gained notoriety as the agent used to combat anthrax in the Hart Senate Building on Capitol Hill, and U.S. postal facilities in New Jersey and Washington, D.C. Because of its history of use by various industries, statistical data on chlorine dioxide's safety is available from the U.S. Environmental Protection Agency, and the U.S. Occupational Safety and Health Agency.[3]

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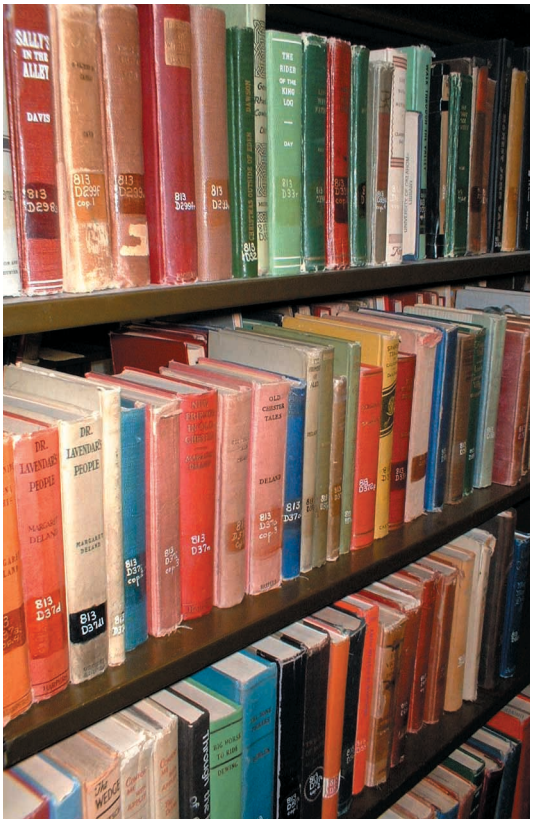
A chlorine dioxide wet wipe solution was used by workers to clean the exterior of each book in the affected section of the 1932 decks. Employees wore gloves and applied the chemical with cheesecloth pads. The books were spread out and dried, then reshelved. Shortly thereafter, additional problems with the air handling system occurred that permitted more mold to grow in the same area. Once the system was repaired, a hand-held fogger filled with a gaseous solution of <0.02% activated, stabilized chlorine dioxide was used to fog the decks, as well as the air system's intake and outtake vents. Despite a later problem with the air handling system that caused temperature and humidity to fluctuate, no further mold outbreaks have occurred in this area.

In the summer of 1997 a similar problem occurred in a small section of the library's 1958 addition. Following a campus-wide air conditioning failure, mold was discovered growing in a closed collections storage area. Like the decks, this area contained books and collections on steel shelving in a room with minimal airflow. Attempts to control the mold bloom

Self-activating chlorine dioxide packets hung in one of OU's special collections areas.

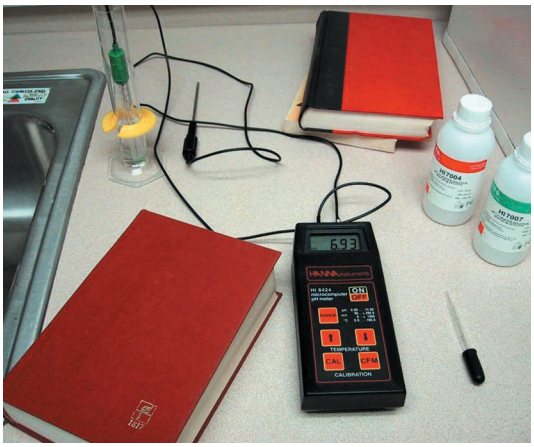


OU decks where the 1991 mold bloom occurred.

through wiping the materials with liquid chlorine dioxide were unsuccessful due to the unusually high mold spore count present in the room. The combination of cleaning the affected volumes, plus strict humidity and temperature controls were simply not enough to effectively manage the situation. Instead of fogging the area in the same manner as the decks, library administrators decided to try chlorine dioxide in a new format. Self-activating packets of chlorine dioxide marketed by the Engelhard Corporation under the brand name "Aseptrol" were used.[4] The small packets contain powder that reacts with humidity in the air to release chlorine dioxide in gaseous form. A total of six packets were hung with wire ties between the bookshelves, in a closed area that measures about 12,000 square feet. This approach stopped the mold bloom, and no subsequent infestations have been found in this area.

As a result of the success of chlorine dioxide in these areas, the University Libraries continue to use chlorine dioxide packets to control mold growth in emergency situations, as well as in areas that require regular treatment due to fluctuating temperature and humidity levels. In the spring of 2003, a steam pipe burst under the branch library that houses architecture materials, creating an ideal hot and humid environment for a mold bloom. Chlorine dioxide packets were immediately hung after the steam pipe was repaired, and to date no mold growth has been detected.

The University Libraries also have found that chlorine dioxide packets are particularly well suited for controlling mold growth in special collections areas, which often consist of small, enclosed storage areas that do not receive much traffic from library employees or patrons.



Test instruments used to measure paper acidity after the use of chlorine dioxide.

The self-activating chlorine dioxide packets can be hung and left to work without requiring constant monitoring by library staff. The regular presence of mold eradication chemicals in areas with unstable environments or a past history of mold infestation provides an added level of security for susceptible collections.

As a follow-up study, in 2000 the University Libraries conducted a test on the library materials that were treated with chlorine dioxide in the 1991 mold outbreak in the decks.[5] This test was designed to determine whether any unintended negative effects resulted from the books' exposure to chlorine dioxide. The tests focused specifically on paper acidity by measuring the pH levels of the paper in books that had been wiped and fogged with chlorine dioxide, and compared them to similar books that had no exposure to chlorine dioxide. The tests were conducted using a microcomputer pH meter with a flat sensor electrode attachment. The meter allowed for direct measurement of paper pH, expressed in numeric values, and had an added temperature electrode that compensated for fluctuations in temperature during the testing process. A group of 250 books that

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Archival Products Updates

Conservation Buckram

Since LBS/Archival Products introduced Conservation Buckram 5 years ago, we have continued to work with the manufacturer to obtain a consistant material with a better hand. The improved E-grade Conservation Buckram is very easy to work with, remains flat and has excellent adhesion with PVA. Along with making manufacturing enhancements, we have expanded colors available from four to eight. In addition to the original colors of black, blue, tan and gray, we have added brown, green, red and maroon. The price of a full-width roll is reduced with slit roll pricing remaining at previous prices.

COLOR	NUMBERS
Black	875
Blue	843
Tan	860
Gray	892
Brown	867
Green	837
Red	802
Maroon	808

CATALOG NUMBER	SIZE PER YD	PRICE
XREB1	Full width 54" roll	$5.08
XREB2	2" roll	$ .50
XREB3	3" roll	$ .75
XREB4	4" roll	$1.00
XREB5	5" roll	$1.25
XREB6	6" roll	$1.50

Available in full 50 yard rolls only.
Minimum cut pieces: 25 pieces per size and color.
Please call for a quotation.

Contact us for a color swatch book today at 800-526-5640 or info@archival.com.

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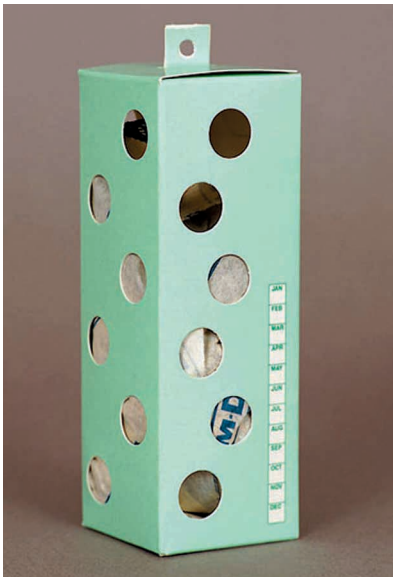
For your convenience recent *Archival Products NEWS* articles will be available on our website at http://www.archival.com/newsletter.html



Star Bright mildew control bags absorb excess moisture, cleans air particles, and inhibits fungi growth.

had been exposed to chlorine dioxide were compared to a similar group that received no chlorine dioxide treatment. The results were satisfactory, showing that the treated group's average pH registered at 5.22, and the untreated group's average pH was 5.31. An independent means *t* test was performed on the pH statistics, which showed that no significant difference in pH levels (T-value = 0.943) existed between the paper of treated and untreated books.

Many libraries with mold problems may find that proper temperature and humidity controls and non-chemical techniques (such as book vacuuming with HEPA-filtered machines) work fine to control a moderate outbreak. However, those who find that standard treatments are not enough to stop mold growth can consider chlorine dioxide as an alternate solution. The University of Oklahoma Libraries continues to use chlorine dioxide to treat problem areas within the collections, and will continue to evaluate and document its long-term effectiveness.

NOTES:

1. An in-depth treatment of the University of Oklahoma Libraries' early use of chlorine dioxide against mold is available in Patricia L. Weaver-Meyers, Wilbur A. Stolt, and Barbara Kowaleski's "Controlling Mold on Library Materials with Chlorine Dioxide: An Eight-Year Case Study," The Journal of Academic Librarianship 24 (1998): 455-458.

2. Simpson, G. D., R. F. Miller, G. D. Laxton, W. R. Clements. "A Focus on Chlorine Dioxide: The 'Ideal' Biocide." Online, Chlorine Dioxide Water Treatment Resource Center. Available: http://www.clo2.com/reading/waste/corrosion.html (accessed May 12, 2003).

3. Toxicological Review of Chlorine Dioxide and Chlorite, U.S. Environmental Protection Agency (Washington, D.C.) Available: http://www.epa.gov/iris (accessed May 12, 2003); the most current statistics from OSHA are available at http://www.osha-slc.gov/SLTC/healthguidelines/chlorinedioxide/recognition.html (accessed May 12, 2003).

4. The Engelhard Corporation no longer supplies Aseptrol packets. Similar chlorine dioxide packets can be obtained from most boating supply stores, which refer to them as "mildew control bags" for use on boats and boat houses.

5. For further information on chlorine dioxide and paper acidity testing, see Kristina Southwell's "The Use of Chlorine Dioxide as a Mold Treatment and Its Effect on Paper Acidity: A Case Study." The Journal of Academic Librarianship 28 (2002): 400-405.

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Coping With a Mold Outbreak in the Archives

by Pat Morris

An outbreak of mold is one of the most common problems in any archive or library in a humid climate. In South Carolina, no summer ever passed without at least one call from a frantic archivist or librarian who had just discovered mold growing in his/her collection. In many cases, mold blooms in the days following a temporary failure of the air conditioning system. It doesn't have to be a collection of older archival materials, either. While at the South Carolina Department of Archives and History, I received calls from hospital record rooms, county court clerks, and college library periodical rooms, as well as from special collections, historic house museums, and archives. Mold will infest virtually any type of organic-based material: film, paper, cloth, wood, or leather.

Mold is such a successful organism because there are so many different types which thrive on an astounding array of food sources. Mold also has an incredibly efficient reproductive mechanism—the spore. The atmosphere and the collections contain hundreds of different types of mold spores. Your collections provide a wealth of food sources for mold. The spores lie dormant, requiring only the proper combination of environmental conditions—heat, water (or high humidity), and stagnant air—to bloom and begin the feast. Even if you maniacally clean your collections before you put them on the shelves, you cannot be sure of a clean environment. An old air conditioning system may be producing millions of mold spores, spewing them into the atmosphere and onto the collections. This was the case at the South Carolina Department of Archives and History, and this article relates what we did when we thought we had mold actively growing on our materials, only to discover that we had a major threat to our collections and personnel in the building's ventilation system.

Initially we became concerned about many volumes with large patches of black "fuzzy" smudges on bindings, text blocks, and in the gutters and end sheets. A closer look revealed hundreds of pages of mildew damage and brightly colored mold stains. We had no records showing that this apparent mold had been there when the volumes were accessioned. There had been major failures of the heating ventilating and air conditioning (HVAC) system the summer before we first took note of this damage. As we surveyed the collections in an organized fashion, we began noting and bagging the damaged books and many boxed records.

We made a deliberately informed decision about bagging the items. We recognized that an active mold infestation would grow more rapidly inside a plastic bag. But we had no storage facility to which we could transfer these materials. Concerned about the spores spreading to the rest of the collection, and worried about the respiratory health of the staff members who had to work in the stacks, we opted for the bags.

We took further action. We submitted samples of the mold to the labs at the Department of Health and Environmental Control. We expected confirmation of our worst fears, but their response was inconclusive. While they could not get the samples to grow in cultures, they informed us that this was no guarantee that we did not have active mold spores in the collection. Concerned that we might have another

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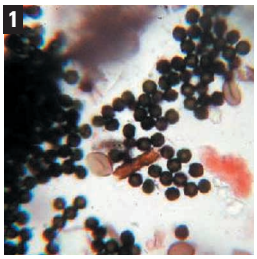
HVAC failure which could lead to a major bloom of mold in the collections, we pursued further expert advice by contacting a member of the university's biology department. An experienced mycologist, Dr. Gerald T. Cowley, came on site and took extensive samples, not just from the bagged materials, but also from the shelving, walls, and air ducts. His test results confirmed that the patches of fuzzy "growth" on the collection materials did not contain viable mold spores. However he did find that we had alarmingly high levels of viable mold spores everywhere else in the building—about 100 times more mold spores inside our building than were present in the open air outside the building. The air samples from the HVAC vents inside the building were especially "rich", generating dozens of different types of molds in the cultures. Some of these were harmful to human beings and many fed primarily on cellulose—the main ingredient in paper. He pointed out one species of mold in particular; it is so successful in breaking down cellulose that the paper industry uses it in their manufacturing process to break down old paper for recycling.



Mold Spores
1) Memnoniella
2) Claolosporium

What did this mean for us? Our twenty-five-year-old HVAC system was generating viable mold spores in significant amounts every day. As long as the system maintained temperatures below 75 degrees and relative humidity below 55-60%, our collections would probably remain free of active mold growth. During the previous summer's HVAC malfunction, the relative humidity rose far above 60% for more than two weeks while the maintenance crews worked to resolve the problems. We knew we were on thin ice. It would take millions to replace the HVAC system, but we could clean the mold out of the system and clean up the stacks for a few hundred thousand dollars. Using the information from our consultant, we convinced the legislature to allocate funds to clean up the collections and the HVAC system.

We reviewed a number of options. We considered killing the mold by applying fungicides. One vendor promised us great results with a solution that could be sprayed on the collections and the shelving and in the duct work. It would kill all live molds and leave behind a fungicidal layer to prevent any new outbreaks. The problem with this "solution" is that it might kill most blooming mold, but it couldn't kill viable mold spores. Over time, the layer left behind as a fungicide would become a food source for mold spores. If the relative humidity rose high enough long enough, the mold would begin to grow again. Furthermore we were uncertain about how the chemical treatment would interact with the various bindings, film, and photographs in the collection.

The archival literature generally provided information on techniques (some out of date) that deal with mold in small amounts. Nothing really addressed an entire building full of archival materials. In the end, we abided by the general principles of modern conservation: use as few chemical treatments as possible; be sure that treatments are reversible.

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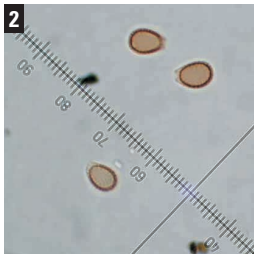
used a firm called Duct Doctor. They used no water or chemicals and created a combination of vacuums and high powered air pressure to clean all the ducts. All filters were replaced, and they found filters well up in the system that had clearly been there since the equipment was installed. They cleaned out things like soda cans and sheets of insulation, all thickly covered with dirt and grime. Next, we had all the boxes, books, and other containers in the collection cleaned with HEPA filtered vacuum cleaners. Before cleaned containers and volumes were put back on the shelves, the shelving was washed with a three-to-one solution of plain water and isopropyl alcohol. The alcohol was added primarily to help the water evaporate more quickly. All walls, ceilings, and floors were also vacuumed.



1) Alternaria
2) Ganoderma basidio spores

After the general clean-up, we continued to retain the services of our consulting mycologist. We purchased an air sampling kit for his use, and he continued taking samples from the stacks and work areas. Spore counts had dropped dramatically. He continued to find some viable spores, but the numbers were well below the samples taken outside the building for comparison. More than half the samples from the stacks yielded no viable spores at all.

Finally we carefully checked all new materials added to the collections. Any suspicious items were vacuumed by the conservation staff before they were added to the collections. While doing this work, the staff wore properly fitted respirator filters designed for the filtration of spores (not just dust). They used Nilfisk vacuums with adequate HEPA filtration and appropriate extensions for delicate work. All old boxes were exchanged for new clean archival containers.

We found that our HVAC system functioned more efficiently. Of course we continued monitoring the temperature and humidity to be sure that any elevation of either was addressed by plant personnel immediately. As an added precaution, we installed large utility fans (manufactured by BARCO) in all the stacks to circulate the air when the HVAC system malfunctioned again, which was inevitable, given its age.

Within five years the state constructed a new archives facility. The design parameters of the new facility included strict environmental standards for the stacks: 60° F and 40% relative humidity. The only way to prevent a future mold problem is maintenance of acceptable environmental standards.

We learned a number of lessons from our experience.

1. Most of the preservation literature concentrates on coping with small mold infestations. As research continues, advice and techniques for handling mold change; but the most up-to-date information on issues related to mold (though not always specific to archives and libraries) is Ellen McCrady's publication and website *The Mold Reporter* (http://moldreporter.org/). A convenient collection of brief publications on mold is also available through the Conservation On Line (CoOL) website (http://palimpsest.stanford.edu/bytopic/mold/). Hilary Kaplan's article reprinted there is very helpful, particularly its information on the acquisition of proper safety gear. The National Parks publication provides some outdated advice on

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Avoid chemical solutions. They do not kill all the spores and may cause health problems.

Rainbow Vacuums, but they do include sources for other equipment including Nilfisk vacuums. One of the best articles available on the nature of biological infestations is from the museum literature, written by Canadian conservator Mary Lou Florian (http://www.uni-muenster.de/Forum-Bestandserhaltung/kons-restaurierung/sch-florian.shtml). The Chicora Foundation published a solid piece entitled *Mold: Understanding the Problem and Recovering Safely.* Twelve pages long, it's a handy reference for $2.00 plus shipping fees if you order less than 50. Order it through their website http://www.chicora.org/; find it through the search engine.

2. Avoid chemical solutions. They do not kill all the spores and may cause health problems. Continuing research has usually revealed that the chemicals that kill mold will weaken the paper. The chemicals may leave a residue that will one day become a food source for mold spores.

3. There is no "quick fix" once you've had a mold outbreak. After you have eliminated the blooming mold, you will always have to be vigilant about cleanliness, temperature, and humidity levels. If your mold outbreak occurred because of a water leak, repair the structural damage and install water alerts. Continue checking for re-bloom.

4. Clean all new acquisitions before they are placed in storage with the rest of your collection. At an absolute minimum, train staff to be alert to signs of mold and mildew when they take in new materials.

5. Exposing the infested materials to sunlight or ultraviolet light will not kill mold effectively, but it can irreversibly damage your materials. Limited exposure to sunlight will speed the drying process, but air drying using fans is just as effective and does less harm in the long term.

6. It's possible to curtail outbreaks of actively growing mold by circulating air with fans when the humidity levels rise. But you must be conscientious in advising people in the area that they risk exposure to mold spores. Some people may have very sensitive respiratory reactions.

7. Document any mold damage you find during the initial inventory; and then document any remedial action you take during acquisitions and processing.

Pat Morris was at the South Carolina Department of Archives and History from 1987 to 2002. She is now a preservation librarian at the University of Colorado at Boulder. She can be contacted at Patricia.Morris@colorado.edu.

Archival Products Update

Acid-pHree Binders Board

Due to energy, pulp, and chemical increases the manufacturer of our acid-pHree binders board has raised their prices. Although we do all we can to keep product costs down to avoid raising prices, we cannot prolong passing this increase on.

Beginning July 18, 2004 acid-pHree binders board prices are as follows.

CATALOG NUMBER	THICKNESS	QUANTITY PER BDL	SIZE	PRICE PER SHEET
DAFBB-1	.074	20	26 x 38	$2.61
DAFBB-2	.086	18	26 x 38	$2.90
DAFBB-3	.098	15	26 x 38	$3.47