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Working Outside the Guidelines: Preventive Conservation for All

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Introduction

Preventive conservation is a nascent major at the Winterthur/University of Delaware Program in Art Conservation (WUDPAC). As a preventive major, I worked on many projects to develop skills in the specialty, and contribute to research for the field. For my presentation at the 2019 Association of North American Graduate Programs in Conservation (ANAGPIC) in Los Angeles, I discussed three of these projects. I introduced the research I completed on a possible fungistat, linalool, and an examination of its microbiological effect on the fungal genus, *Cladosporium.* I also presented on a research project to measure for gaseous elemental mercury (GEM) coming from degrading tin-mercury amalgam mirrors using a low cost method developed for the artisanal gold mining industry. Finally, my presentation included an introduction to the work I completed with teaching high school students collections care techniques for their school's large collection of cultural artifacts. These projects demonstrate the need for preventive conservation to adapt to less than ideal conditions and come up with innovative strategies to collaborate and work outside traditionally prescribed guidelines.

Fungistat Research

Mold outbreaks are increasingly becoming a problem within collections around the world, and there are many efforts to examine preventive strategies outside of mechanical environmental control (Borrego et al. 2012; Stupar et al. 2014; Noshyutta et al. 2016). The use of environmental control is not always possible in certain climates around the globe, and the energy-intensive mechanical systems are unsustainable and contributing to the climate changes responsible for the increased risk in mold. For my research, I decided to follow up on the 2005 and 2007 research completed by Dr. Rakotonirainy and Dr. Lavédrine looking into essential oils and their components as possible fungicides and fungistats in library collections ((Rakotonirainy and Lavédrine 2005; Rakotonirainy et al. 2007). The ultimate focus of their research was a monoterpene alcohol, linalool, which they found to have fungistatic properties, but determined that it may have a negative effect on paper, photographs, and leather (fig. 1). The researchers attributed this degradation to the compound's allylic structure and its

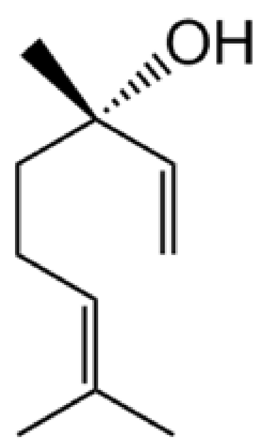

Fig. 1. *The chemical structure of linalool*

ability to form a hydro peroxide product (Sköld et al. 2002; Rakotonirainy et al. 2007). I decided to do further research on linalool since it is incredibly common in commercial products and because essential oils are actively being used near collection areas.

Fig. 2. *Preparing textile samples to be exposed to linalool prior to artificial aging*

I decided to specifically evaluate the effect of linalool on silk and cotton textiles to represent proteinaceous and cellulosic materials. I prepared samples of both and placed them into a test tube with saturated salts to maintain the relative humidity, and exposed half of the samples to a known concentration of linalool for three weeks (fig. 2). I then proceeded to place half of these samples into an aging oven at 60% RH and 80° C for 21 days to mimic the research of the studies I examined. In order to evaluate any degradation caused by the exposure to linalool, I used tensile strength testing to measure mechanical strength, scanning electron microscopy (SEM) for distinguishing morphological changes, and Fourier Transform Infrared Spectroscopy to determine the level of oxidation on the samples (Koperska et al. 2014).

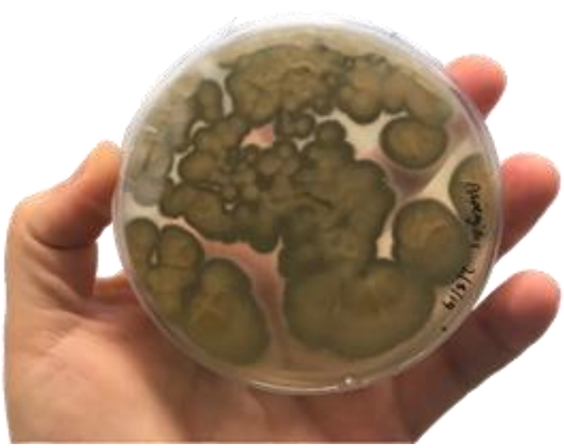

Fig. 3. *A potato glucose agar plate with a colony of* Aspergillus

For another portion of the study, I wanted to reevaluate the fungistatic properties of linalool on cotton textiles. Thanks to the guidance of microbiologists at the University of Delaware, Nancy Fisher Gregory and Dr. Julie Maresca, a methodology was established. Fungal colonies were collected from moldy textiles and inoculated onto potato glucose agar medium plates and incubated at 25°C (fig. 3). The genus *Cladosporium* was identified by Nancy Gregory and was chosen for its ability to produce the cellulase enzyme and therefore more likely to be found on cotton textiles.

Fig. 4. *A photomicrograph from the Hirox RH-2000 digital microscope showing the blue-stained hyphae of the mold amongst the cotton fibers of the textile.*

For the experiment, sterilized cotton samples were inoculated with a broth solution of suspended *Cladosporium* conidia and hyphal fragments of a known concentration.[6] Once inoculated, the textile samples were placed within a sterilized glass test tube with a small vial of water and for half of the samples, a known volume of linalool was pipetted at the bottom of the glass. The test tubes were sealed with a silicone stopper, Parafilm®, and Teflon® tape, and placed within the incubator at 25°C for 72 hours. A technique for staining fungi on cellulosic plant material was adapted for the cotton textile samples. A lactophenol solution with 1% trypan blue dye was effective to make the hyphae of the fungi more visible amongst the cotton fibers of the textile (Chia-Lin Chung, 2006). A Hirox RH-2000 digital microscope was used to determine the diameters of the colony forming units growing on the textiles as this provides information about the effectiveness of the fungistat as seen in figure 4.

Measuring Mercury Vapor from Mirrors

[6] Spore counts were determined manually using a hemacytometer.

Fig. 5. *The raking light makes the mercury drips more visible to cleanup with a specialized mercury spill kit*

Mercury-tin amalgam mirrors, or looking glasses, were the dominant mirror manufacturing method from the 16th through the early 20th century (de Chavez 2010). An alternative process, slivering, was invented in 1835, however, it was not widely used and accepted until the early 20th century when the dangers of mercury were more well-known (Torge, 2010). The liquid mercury in the mirrors has been known to actively drip and splatter into minuscule droplets onto collection or storage floors (Swan, 2010). This makes for a time-consuming and dangerous cleanup process. Raking light is effective at helping to find mercury drips, but as evident in figure 5, the drips can be very small and therefore difficult to know if all of them have been located.

In 2015, a previous WUDPAC graduate fellow, Leah Bright, did research on determining effective ways to identify tin-mercury mirrors using XRF (Bright, 2016). In the summer of 2018, Dr. Rosie Grayburn and Catherine Matsen implemented the technique in Leah's research and concluded that at least 63% of the 243 mirrors in Winterthur had this particular mercury amalgam. Based on this data and conversations with curators and conservators, it is evident that these types of mirrors and their active dripping of mercury is likely a problem in many collections.

Affiliated Professor at WUDPAC, Dr. Rosie Grayburn, discovered research based out of the University of Victoria in Canada that developed low-cost sensors to measure mercury vapor levels (de Barros Santos et al. 2017). The sensors were developed for the artisanal mining industry that uses liquid mercury as a means of extracting small amounts of gold out of mining dust. The sensors were developed to work similarly to a dosimeter and measure the long-term exposure of mercury vapor on individual miners. The sensors are paper filter membranes that are impregnated with gold nanoparticles and reduced. The researchers have discovered a direct correlation between the color change of the sensor and the exposure to mercury vapors.

An actively-dripping mirror from the Winterthur collection was stored within a small closet for the duration of the study. The sensors were placed in assigned locations around the closet as a way to measure mercury vapor levels as it moves throughout the room. Our hope was to test a possible storage option for the mirror that would capture the liquid mercury droplets in a way that allowed for easy collection and disposal. We did this by taking measurements of the mirror without an enclosure followed by measurements when the mirror was encapsulated within a polyethylene sleeve to collect the dripping liquid mercury as seen in figures 6 and 7.

Figs. 6,7. *The polyethylene bag created to contain the mercury drips on mirror.*

Prior to the start of the experiment, the University of Delaware Environmental Safety Department used a Jerome® 431-X sensor to get an initial reading of the mercury vapor levels after the mirror had had about a month to acclimate to the closet storage space. The highest recorded reading was 0.00265 mg/m^3 when the NIOSH and ACGIH® TLV® permissible exposure limits (PEL) over an 8-hour shift are 0.1 mg/m^3 and 0.025 mg/m^3 respectively.
The readings were far below any of the limit, which made us more comfortable about our safety in entering the space with the mirror. The Jerome® 431-X sensor is a very expensive instrument, which is something not accessible to many institutions storing these mirrors and concerned about human safety.

In order to measure the color change of the sensors over time, we used an LED microscopic attachment on an iPad to collect the images at a fixed focal point with consistent lighting as seen in figures 8 and 9. The study required regular photography of the sensors at specific times, up to 3 times a day, and on some weekend days. Each iteration of the study took about a month, and the research required the assistance of 15 volunteers from WUDPAC graduate fellows and faculty members, which made the project an excellent way to develop project management skills. The sensors may have promise to be an excellent low-cost way to monitor for GEM to ensure safe conditions near collection items containing mercury.

Figs. 8,9. *The microscope attaches to the iPad and provided consistent lighting and a fixed focal point for the photographs of the sensors*

Central High School

Central High School is a competitive public magnet school located in north Philadelphia. It has a very active alumni association, and a large collection of art and cultural artifacts as a result of alumni donations. The art teacher at Central High School, Andrea Keefe, was concerned about the care of these objects and their long-term preservation. She and a group of teachers were also eager to brainstorm ways to incorporate these objects more into their teaching, and bring more meaning for them to the students in the school. Ms. Keefe reached out to a local conservation regional center for help. The center referred Dr. Joelle Wickens, who saw this as a wonderful opportunity to teach our class at WUDPAC about survey work in our first-year preventive conservation course.

The survey was completed in May 2018 with the goal to evaluate the present risks for the objects and propose some short and long-term goals for the school to improve the care of their collections. I continued to work with the high school into my second year at WUDPAC as part of my course, Preventive Conservation Research and Applications. Following the survey, I was especially concerned about insects since I had found several instances where active pest damage was evident as seen in figure 10. Due to limited space in the dining hall, students are allowed to eat all around the school, and dust has collected in the cases and on the objects. It was evident that the collection items would benefit from a regular cleaning regime.

Fig. 10. *Insect frass was found near the base of an object within the collection*

Ms. Keefe already had a group of 10 students devoted to helping with the school's collection for their required community service. Most of these students were in her art classes and had an interest in art and cultural artifacts. For one of the earlier visits to the school, I compiled a group of University of Delaware art conservation students and teachers to assist on an item-level survey. The goal for the survey was to evaluate the stability of the objects for potential dry surface cleaning. The survey involved the high school students, who quickly picked up on the conservation terminology and were curious and engaged learners.

Fig. 11. *Dr. Rosie Grayburn showing a student how to interpret the XRF spectra after taking a reading of an object (Note: the students were not near the spectrometer when it was emitting x-rays)*

Due to the large collection of organic objects, it was crucial to raise awareness about the potential risk of pesticides. Dr. Rosie Grayburn, graciously volunteered to join for the day of the survey to use the portable XRF as a way to locate the presence of heavy metals (fig. 11). It was also an excellent opportunity to teach students about spectroscopy for elemental analysis and show them how science is so deeply entwined in art conservation. There have been several opportunities to teach the high school students about conservation during the visits to the school this semester. For example, Dr. Joelle Wickens served as a guest lecturer for an AP Environmental Science Class. The students had been learning about the use of pesticides and integrated pest management (IPM) in the agricultural industry, and the teacher was eager and excited to hear about the conservation field's adaptation of IPM and the risks we face with objects that have been poisoned with pesticides. For a later visit we worked with the students to perform an anoxic treatment for some of the objects that exhibited pest activity.

During a later visit to the school, I worked with my classmate, Joanna Hurd, to teach the students about object handling and various dry surface cleaning techniques on the objects. The students were excited to see the results of their efforts and picked up on the techniques quickly. In order to encourage the continuation of the project, I developed a lesson plan and informational packet for the students. Based on an earlier discussion with them, it was determined that short videos would be the most effective way to reinforce the lessons. This was achieved through a curated selection of existing online videos, and the filming and editing of others. An example of one of these informational videos is an animation I created on the dangers of dust to illustrate the need for regular cleaning. This project with Central High School is just the beginning of a fruitful collaboration with the University of Delaware Program in Art Conservation.

Conclusion

While these projects represent the variety within the preventive conservation major curriculum at WUDPAC, there is an important common theme. These projects were all developed from real world problems where ideal conditions are difficult to attain and resources are limited. For a long time, preventive conservation was seen as a movement to create rules to follow, but in reality, it is more about coming up with the best ways to work outside of the prescribed guidelines. Issues such as sustainability, climate change, and access are guiding us towards innovative preventive strategies. It is much easier to point out things that are being done wrong, however, as I have been learning more about preventive conservation, I am finding that it is crucial for us to point out the things that are being done right, and figuring out ways to make things work even when it does not seem possible. If more people in the conservation field adapt this outlook, it seems likely that we will be a crucial component to conservation decision-making and planning.

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