Woe is the Wallpaper: Hazardous Pigments in Unexpected Places

Wallpaper: Where and What?

Decorative wallpaper is often found within historic buildings pasted upon the walls and ceilings. Multiple layers of paper may be present due to changing fashion over time, or they may have been added to cover up faded pigments, wear, or damage. Wallpaper was not always pasted to rigid surfaces such as plaster walls or wooden boards; it may have been tacked onto a wall along the borders or even adhered to canvas and allowed to hang over the wall. Scraps of wallpaper can be found lining the inside of furniture, inside hat boxes, and on fireboards, or may have been used to decorative dollhouses and other objects. Spare lengths of wallpaper may be found rolled up and stored in attics. If wallpaper sample books are part of a historic building's collection, they can offer significant information about manufacturing history and fashionable designs. Additionally, impressive collections of wallpaper are often cared for in museums such as at the Rhode Island School of Design (RISD) Museum (Figure 1).

Hazardous components were integral to many popular pigments and flame-resistant products used in historic wallpaper production. Whether within a laboratory setting, a museum environment, or a historic building, understanding the potentially hazardous materials present in historic wallpaper will help to inform safety protocols that can best protect curators, conservators, and other caretakers of collections.

Figure 1. Accession no. 34.1005. Courtesy of the RISD Museum, Providence, RI.

Hazardous Wallpaper Pigments

The primary hazards when managing, handling, and treating historic wallpapers are found in the pigments, although asbestos additives may also be present. More information on specific colorants and/or pigments can be accessed on the CAMEO website. Work carefully when assessing wallpaper with these pigments!

Red: Mercury and Lead

Examples of red pigments commonly used in historic wallpaper include vermillion and red lead. Vermilion and cinnabar are chemically identical and are both red mercuric sulfide; cinnabar is a naturally occurring metallic ore whereas vermillion refers to both the ground cinnabar version and the synthetic form created from heated and vaporized mercury and sulfur. Pigments used in traditional Chinese wallpaper reference the use of the ground mineral, whereas European wallpaper examples tend to reference synthetic vermillion. Red lead (lead tetroxide) was inexpensively manufactured by heating white lead over a long period of time, which produced a poor-quality product with low light stability.

Yellow: Chromium, Arsenic, and Lead

Chrome Yellow (lead chromate) was discovered in 1797. However, manufacture of this lightfast pigment began later, in 1809, and was more widely available and used by wallpaper producers after 1820 through the early 1900s. Orpiment (an arsenic sulfide mineral) and its orange-red toned degradation product realgar, are naturally occurring pigments that have been in use since antiquity, but the 18th century development of a cheaper, synthetic orpiment made of sulfur and arsenic oxides led to its wider application in wallpaper designs.

Blue: Cyanide

Prussian blue (potassium ferric ferrocyanide) was first developed in Berlin in 1704 by paint manufacturer Diesbach and pharmacist Johann Konrad Dieppel. This lightfast pigment began manufacture in 1710 and became widely used due to its strong coloring power and affordability.

Green: Arsenic

The launch of arsenical pigments printed and painted onto wallpaper began with Scheele's green. Discovered in 1775 by Swedish chemist Carl Wilhelm Scheele, copper arsenite produced a vivid green that became a popular pigment for interior decorations; the first English instruction for manufacture was published in 1812. Scheele's green darkens in the presence of sulfur and lead compounds, so the recipe was improved upon in 1814 by Wilhelm Sattler by producing copper acetoarsenite, known by many familiar names such as Schweinfurt green, Paris green, Emerald green, and English green. Schweinfurt green will also darken over time if exposed to sulfurous air pollutants.

White: Lead

Lead white (lead hydroxycarbonate) was used in printed wallpaper for highlights and other areas that required brighter tones. Depending on environmental conditions, aged lead white pigments can appear yellowed or blackened.

Toxic Components of Wallpaper Pigments and Their Health Effects

Arsenic

The use of arsenic-based pigments in wallpaper and their negative health effects is the subject of many articles and other published works. Arsenic's low cost and accessible characteristics paired with its incredible ability to create vibrant colors led to its popularity as an ingredient in a wide range of pigments applied to wallpaper, including the greens and yellows previously mentioned. Manufacturers generally stopped producing arsenic-laced wallpapers in the late 1800s.

The main routes of exposure for arsenic are ingestion and inhalation; dermal absorption may also occur at a much lower rate (CDC 2010). If introduced into the body, most arsenic will be expelled in urine within several days though it will likely take longer to leave in keratin-rich tissue such as hair, nails, skin and to a lesser extent teeth and bones. Lung cancer, peripheral nervous system damage, vascular damage, kidney and liver damage and skin lesions are all symptoms of prolonged arsenic exposure (H&SN 2017; CDC 2010).

When arsenic-containing pigments are combined with water or acids, arsenic and the hydrogen form arsine gas (AsH3) which is a highly toxic gas that may be inhaled upon exposure (CDC 2011). Environmental conditions with high moisture levels elevate the risk of mold growth which can accelerate the production of arsine gas. A delayed display of hemoglobin in urine samples, abdominal pain and jaundice are all symptoms of short-term (less than 8-hours) exposure to arsine gas (CDC 2011).

Mercury

The main routes of exposure for mercury are ingestion, inhalation, and dermal absorption (Mercury 2019). If introduced into the body, inorganic mercury can settle in various organs, usually the kidneys, but most will eventually leave the body after several weeks or months (Risher 1999). Damage to the central nervous system and kidney damage are all symptoms of prolonged mercury exposure (H&SN 2017).

Chromium

The main routes of exposure for chromium are ingestion, inhalation, and dermal absorption (CDC 2013). The oxidation state of chromium influences its toxicity, with chromium (VI) being more readily absorbed by the lungs, gut, and skin than chromium (III) (CDC 2013). If chromium (VI) is introduced to the body, about 60% of it will be excreted by the kidneys in the form of chromium (III) within 8 hours of ingestion (CDC 2013) The chance of lung cancer is increased upon prolonged exposure to chromium (VI).

Curious about Arsenic in Green Books?

To learn more about the use of arsenic as a colorant for papers and books, attend "Poison Books: Is that Green Book Going to Kill Me? Bibliotoxicology Working Group Discussion Panel" at the 2023 AIC Annual Meeting in Jacksonville, on Friday, May 19th at 10:30 a.m.

Panelists: Timothy Greening, Susan Russick, Rosie Grayburn, Melissa Tedone, Kimberly Harmon, Becky Fifield.

The session is sponsored by the Book and Paper Group (BPG), Research and Technical Studies (RATS, and the Preventive Care Network (PCN)

Lead

The main route of exposure to lead is ingestion, followed by inhalation, and dermal absorption (CDC 2019a). Neurological damages, renal disease, damage to the blood, cancer and reproductive toxicity are all symptoms of prolonged lead exposure (CDC 2019a; H&SN 2017). If introduced into the body, the percentage of lead absorption varies dramatically based on route of exposure, how soon after a meal, health, and age of the exposed individual (CDC 2019a).

Cyanide

Cyanide crystals in the toxic pigment Prussian Blue can emit highly toxic hydrogen cyanide gas when exposed to water, acid, high temperatures, or a strong source of ultraviolet light. The main routes of exposure for hydrogen cyanide gas are inhalation and dermal absorption while cyanide in its crystal form can be ingested (CDC 2023). Respiratory issues, heart damage, nosebleeds and thyroid enlargement are all symptoms of prolonged, low-level, exposure to cyanide (MDCH 2004). Brain, heart, blood vessel and lung damage are all symptoms of hydrogen cyanide gas exposure (CDC 2019b).

Asbestos in Wallpaper

Due to its durable fireproof and flame-resistant properties, asbestos was sometimes included as additive in vinyl wallpaper and was used in mastic compounds to apply wallpaper. Starting in the 1970s with the Clean Air Act (and later revisions), asbestos use declined due to regulations banning its applications (NPS 1989). By 1989, the EPA prohibited most asbestos-containing commercially available products, including adhesive and vinyl products (EPA 2023).

The main route of exposure for asbestos is inhalation, which occurs when the fibers become airborne due to a disturbance of an asbestos-containing product. Lung cancer, mesothelioma, and asbestosis are all major health concerns that can result from long term exposure to asbestos (EPA 2023).

Identification and Handling

Knowledge a wallpaper's production date can help characterize possible hazards and assist in narrowing down a long list of materials to be tested. Awareness of the colors associated with hazardous pigments, such as the vivid emerald green associated with many arsenic-based pigments, can also help narrow the list of potential candidates.

The identification of hazardous materials can inform safe handling protocols to protect the caretakers of wallpaper within a collection.

- Handheld x-ray fluorescence (XRF) is an efficient, accurate, and easy-to-use method for detecting the presence of heavy metals and can effectively determine the presence of many hazardous pigments.
- Microchemical tests can be employed to detect the presence of hazardous pigments. Procedures for microchemical spot-testing to determine the presence of arsenic, mercury, chromium, and lead are outlined in Odegaard (2000). The microchemical testing procedure to determine the presence of Prussian blue is outlined on the AIC "BPG Spot Test" webpage. Take care in handling and using the chemicals required for these tests. For example, a small amount of arsine gas is produced while conducting an arsenic spot test, and it should only be performed in a fume hood or other well-ventilated area.

Objects associated with wallpaper, such as plaster and wood substrates as well as object housing, should be analyzed to determine if hazardous substances have been transferred or if asbestos is present. If toxic substances are found, then conservation professionals can consult with health and safety professionals to determine the appropriate steps to monitor and provide appropriate protocols. An exception, asbestos identification (by various forms of microscopy) is highly regulated in most states and must be performed by a qualified professional.

Safe handling and storage practices can minimize exposure risks and are a necessary precaution when identification of hazardous materials through analysis or microchemical spot-testing is not possible or practical. Wallpaper suspected or known to contain hazardous materials should be minimally handled to reduce exposure, the risk of contaminating additional objects and tools, and the likelihood of creating an airborne hazard. To minimize handling, employ the use of mats and other storage devices which mitigate the risk of transferring potential or determined hazards. If the wallpaper itself requires handling, use appropriate latex or nitrile gloves.

Safe practice dictates that the risks associated with known and suspected hazardous materials should be communicated to those accessing the collection, including visitors, researchers, collections management, and conservators. These risks should be communicated with clear labeling of storage areas, housing, and through health and safety training. The condition of the wallpaper can play a large role in the risk of exposure; wallpaper examples with friable media should be handled with extra care due to the increased risk of inhalation and transfer.

To further limit exposure risk, appropriate personal protective equipment such as eye protection, lab coats, and respiratory protection should be worn as determined by the type of hazard present and the predicted level of exposure. While handling and/or treating wallpaper, practice good hygiene, including frequent handwashing and no eating or drinking near wallpaper with known or suspected hazardous materials. Additional information on the hazards associated with pigments can be found in the AIC Health and Safety: Pigment Health and Safety Quick Guide.

The presence of asbestos requires that the handler follow specific protocols as determined by federal and state law; if asbestos is suspected, enclose the object in a sealed container and avoid disturbing it.

Use caution when multiple layers of wallpaper are present because hazardous pigments may have been used on sub-layers of wallpaper even if they were not used on the outward facing layer. Additionally, it is possible that traces of pigments and other coloring media applied to the surface of a wallpaper may have seeped into the adhering paste or onto the supportive backing material, especially if there has been previous water damage. During treatment, steam or a water bath are common techniques to remove well-adhered wallpaper from its substrate or to separate layered wallpaper; this treatment step should only be considered after the wallpaper has been tested for hazardous materials, most notably arsenic and cyanide, to prevent the formation of toxic gasses with water.

Conclusion

While the negative health effects of arsenic-based green pigments used on wallpaper have long been reported, conservation professionals should also be aware of other common hazardous pigments used in historic wallpapers such as mercury, chromium, lead, and cyanide. Furthermore, asbestos was a popular flame-retardant additive in vinyl wallpaper and mastic during the 20th century.

Reduce risk of exposure through good hygiene, minimal handling, the use of personal protective equipment, and signage and communication. Testing can confirm and guide collection use and handling protocols. Widespread awareness of the potential hazards in historic wallpaper will assist in preventing unplanned encounters.

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Additional Resources

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Join the Health & Safety Network Forum

The Health & Safety Network Forum is a free place for conservation professionals, concerned about the health and safety of others as well as their own, to discuss and learn more about workplace safety. If you have specific health and safety questions, it will help you find relevant, up-to-date information about the topic. Share with your colleagues and networks!

The H&SN Forum:

- Provides a safe space for conservators and allied professionals to discuss the topic without judgement
- Promotes existing health and safety issues and resources
- Assists network officers in developing health and safety content
- Updates the field on changes to the federal government's policies and procedures for health and safety matters
- Builds a strong network of health and safety advocates

Join today! https://www.culturalheritage.org/health-safety-forum

Schedule Your Respirator Fit Test in May

Whether you are using hazardous chemicals in your laboratory or working with mold-infested artifacts after a flood, you need to be protected with a properly fitting respirator.

The Respirator Fit Test at the Annual Meeting, May 18, 2023, will provide the participant with access to an online lecture on respirator selection, care, and use, as well as a 20-minute, individual appointment for a personal respirator fit test, ensuring an acceptable, face-to-facepiece seal/fit of their respirator. The individual appointment provides an opportunity for participants to ask any specific questions of the industrial hygienists, and to examine and/or try on various half-mask, air-purifying respirators from the Network's selection of samples. Please note that you MUST bring your personal respirator for the fit test. The event is $39 or free for CIPP members.

The AIC Fit Test Program is specifically designed for conservators, particularly those who are self-employed or who do not have a respiratory protection program provided through their employer. However, it is open to all interested parties. This workshop is in accordance with the U.S. OSHA Standard (29CFR1910.134 - Respiratory Protection).

A component of Respirator Fit Test is obtaining an OSHA Respirator Medical Clearance Approval from a physician. This service is available from OHS Health and Safety Services Inc. at a discounted rate of $25 for AIC members and is offered by phone or online.

See more in the AIC Annual Meeting Community post about the fit test.