Quantitative Oddy Tests of Materials Used for Book Conservation, Restoration, Display, and Storage

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Introduction: The Oddy Test

In 1973, British Museum's conservator, Andrew Oddy noticed museum artifacts were deteriorating and eroding faster than before. Oddy created an accelerated corrosion test to detect off-gassing of materials to assess safety of materials used around museum objects.

The Test:

Copper, silver, and lead coupons are contained in a hot and humid environment with material for one month. The degree corrosion on the metal coupons determines if the material can be used, can be used for a temporary time, or cannot be used at all.

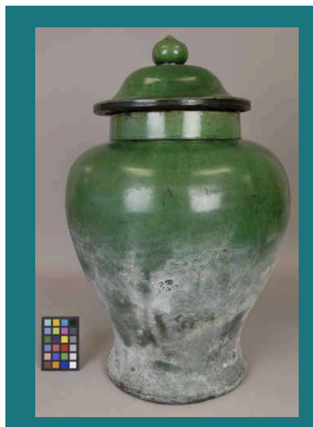
Copper detects chlorides, oxides, and sulfur compounds
Silver detects for reduced sulfurs, and carbonyl sulfides
Lead detects for organic acids, aldehydes, and acids

The Problem:

The extent of corrosion on the metal coupons is determined by the human eye and optical microscopy. This causes subjectivity to the test because some conservators may pass the coupons, while others may fail them. Oddy Test protocols also differ among museums.

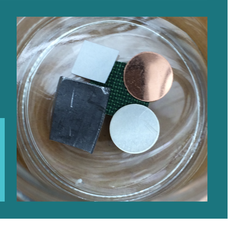
Objective:

To determine the safety of materials in Johns Hopkins University's Heritage Science for Conservation Laboratory by using the Walters Art Museum's Oddy Test protocol and integrating analytical techniques to make more objective conclusions about the use of the materials.



Above, From the MET, a Ming Dynasty jar that was stored in a cardboard box lined with polyester polyurethane foam. Thick, white deposits formed where the foam was wrapped.

Above, our Oddy Test set-up



Right, the set up of our coupons: half on and half off the material in question to test for contact reactions and off-gassing.

Materials Tested:

- *Uline Perforadated Foam Roll:* used for wrapping books up for storage
- *Cialux* (red, blue, green, beige, and grey): a rayon cloth used for covering hardback books
- *Soft tyvek:* protective lining for artwork, textiles, and fragile valuables
- *Thin and thick reemay:* gives support during paper washing, used for interleaving between pages
- *Melinex* (3, 4, and 5 mil): clear, polyester sheet used to protect pages and photos protective
- *Thin and thick texwipes:* used for cleaning
- *Black and green Japanese fabric:* used for covering books and bindings
- *Rolled Blotter*: controls humidity, used for interleaving between pages

Procedure

Followed *Walters Art Museum's* Oddy Test Protocol:

1. Perform Fourier Transform Infrared Spectroscopy on samples
2. Polish copper and silver coupons by machine
3. Polish lead by hand with sponge, first with ethanol and then with acetone
4. Perform Colorimetry on all coupons, filter paper, and samples
5. In a 4 oz. jar, place metal coupons and filter paper partially on sample with a small test tube filled with 2 mL of water and cotton
6. Place sealed jars in oven at 37.7°C for 28 days
7. Analyze all coupons, Whatman paper, and samples using colorimetry and FTIR

Methods:

Fourier Transform Infrared Spectroscopy

FTIR gives an absorbance spectrum that corresponds to organic functional groups present.
Prior to testing FTIR was performed on all sample materials to foresee potential off-gassing.
After 28 days, FTIR was performed on all samples, metal coupons, and Whatman paper to detect organic material forming on the surface of the coupons.
Instrument: Bruker Alpha Platinum ATR-FTIR

Photography

Professional photos were taken of all of the jars and coupons.
This gave an easy way to visually look at all the coupons at once, zoomed in on the computer.
Although this is not a quantitative technique, it is the general way Oddy Tests are evaluated.
Instrument used: Canon EOS 5D

Colorimetry

Colorimeters are hand-held, relatively inexpensive, and easy-to-use instrument that measures the color of a surface.
It was performed on all samples, metal coupons, and Whatman #1 filter paper to quantify change in color after test.
Instrument: Konica Minolta Spectrophotometer CM 700d
Outputs 6 values: L, a, and b values with the spectral component included and the spectral component excluded

- L: lightness of sample (more positive = lighter, more negative = darker)
- a: red/green of sample (more positive = red, more negative = green)
- b: blue/yellow of sample (more positive = blue, more negative = yellow)
- For the average color, E is calculated: $E = \sqrt{L^2 + a^2 + b^2}$

Results and Conclusions

FTIR

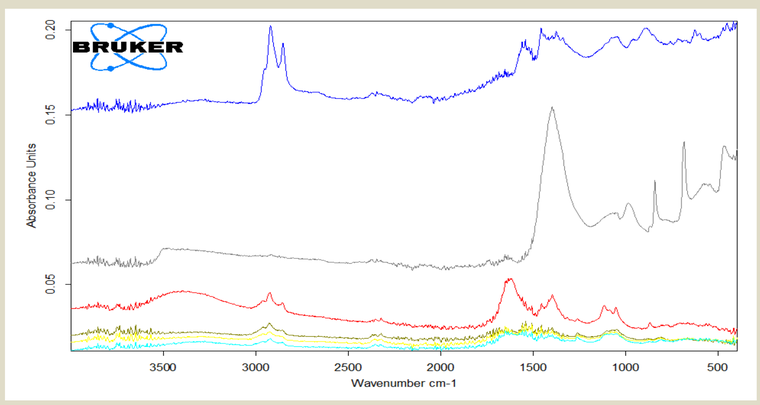
FTIR proved to be a useful screening method to determine which samples should be investigated further. As seen on the right, rolled blotter may have a sulfur containing compound on the lead coupon indicating further tests are needed. Melinex, thick texwipe, the Japanese fabrics showed the presence of other organic materials. More testing is needed to determine whether these chemicals are merely adsorbing, or if there is a chemical reaction present. detected organics on rolled blotter, melinex, thick texwipe, and the backs of the Japanese fabrics.

Colorimetry

Colorimetry was used to determine the color change of the coupons over the course of the test. A delta E value of 2 is visible to the human eye, we are considering anything greater than 2 to be a significant change. Some values were as large as 8. Our colorimetry results are not finalized, but a significant change in color was detected on the rolled blotter, melinex, thick texwipe, and Japanese fabrics. Having both sets of values including and excluding the spectral component was useful, especially on the metals. One will provide surface roughness, and one will provide color change.

Further Investigation:

Further investigation and analysis of Oddy Tests need to be completed to determine whether the materials can be used or not. The samples need to be viewed under optical microscopy and potentially atomic force microscopy. In the future, we hope to identify the gases the materials give off by incorporating gas chromatography-mass spectrometry. The next time we do Oddy tests, both sides of the coupons need to be polished for a more concise analysis.



FTIR Spectra
Blue: thick texwipe, lead coupon, peak at 2900, Teal: melinex, silver coupon, peak at 2900, Grey: rolled blotter, lead coupon, peak at 1400, Red: thick texwipe, silver coupon, peak at 3300 and 2900, Green and Yellow: back of Japanese fabric, silver coupon , peak at 2900

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