Bone Folders for Book and Paper Conservation: An In-Depth Examination

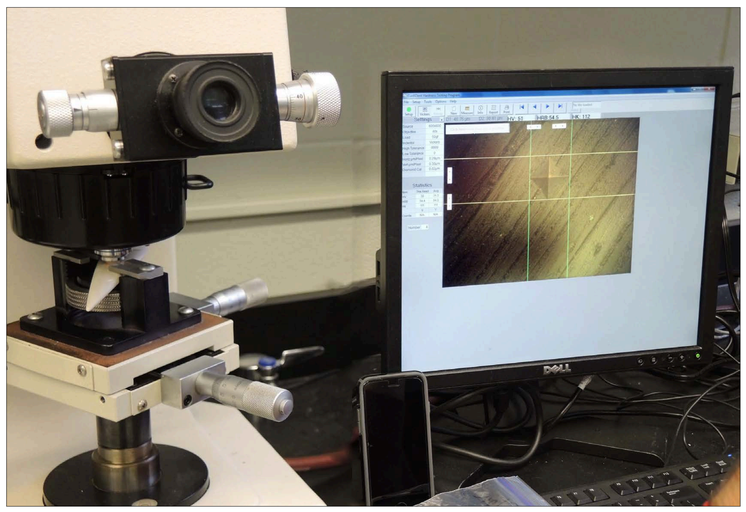
SUMMARY: The bone folder is a common tool used by book and paper conservators. Many folders are typically made from cow bone, but some are fashioned from deer or elk bones. Synthetic materials, such as Teflon and most recently Delrin are also used to make folders. The initial interest in studying these materials started with a discussion of the tradition of applying oil to a bone folder to provide better slip. This poster examines some of the properties of these materials to provide us with a better understanding of these tools. We were fortunate to collaborate with numerous research scientists using the facilities available at Penn State University.

BACKGROUND: Initial interest in this study started during a discussion with Olivia Kuzio, a Bednar Undergraduate Conservation Intern in our Preservation, Conservation and Digitization department. Olivia is a rising-senior majoring in Chemistry at Penn State University, and had already developed a great interest in Conservation Science as a career.

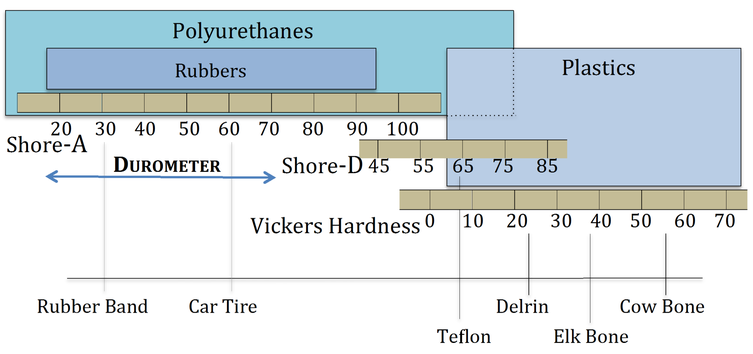
During a discussion about bone folders, we talked about the tradition of oiling a bone folder, as described in Annie Wilcox's book, ***A Degree of Mastery: A Journey through Book Arts Apprenticeship***. Wilcox wrote that she had been instructed to soak a new bone folder in oil, which was thought to provide better slip. A discussion of this passage on the BookArts Listserve made it clear that many readers felt that the oil could be transferred to paper.

With Olivia's background in chemistry, she speculated that we could test for any oily deposit using forensic science techniques including Iodine Fuming or the Ninhydrin Solution treatment.

HARDNESS TESTING: Common bone folder materials were submitted for hardness testing. While many plastics are measured using the Shore A and D Durometer scales, the Vickers Hardness scale is used in our Material Science Labs. In the Vickers test, a diamond stylus is pressed into the material with a specified force. The resulting impression is measured and compared to a known scale to determine the relative hardness. Since there is no direct conversion of the Vickers and Shore measurements, our scale is based on Teflon, which is rated at 65 on the Shore scale, whereas our test shows an average of 7 on the Vickers scale. The resulting hardness of the other bone folders is shown on our scale.



Hardness Tester with bone folder and impression being measured on the monitor and that measurement translates to the Vickers Hardness Scale.



Since there is no direct conversion of Vickers to the Shore A and D measurements, our scale is based on Teflon which is rated at 65 on the Shore-D scale. Our tests showed an average of 7 on the Vickers. The resulting hardness of the other bone folders is shown: Teflon = 7; Delrin = 22; Elk Bone = 37; and Cow Bone = 56, thus a cow bone is the hardest. This hardness will therefore burnish paper more than the softer Teflon, as many conservators already know.

Poster Authors:
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PREPARATION of BONE FOLDERS: We learned that the front leg bones of cows are typically used as well as bones from deer and elk. These bones are typically cleaned by boiling in water for a period of time, and then sawn to a rough size. These are cleaned further by careful boiling -- over-boiling can cause the bone to degrade. Some people add ammonia to the water, but also recommend that bones should not be bleached. The final shape of a bone folder is achieved by sawing and further shaping is done by sanding with various abrasives.

Polishing of bone and synthetic folders: To finish a bone folder, one should consider more polishing after purchase. Very fine, micro-abrasives, such as: 15-micron (approx. 1000grit); 5-micron (approx. 2500grit); and 0.5-micron (approx. 9000grit) abrasives can provide a very smooth finish. These abrasives are available from specialty suppliers. One must be aware of safety issues with such fine particles that will become airborne. All work should be done in water or in a fume hood.

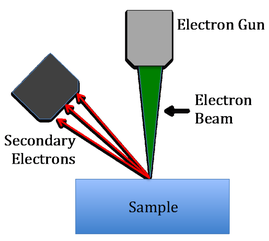
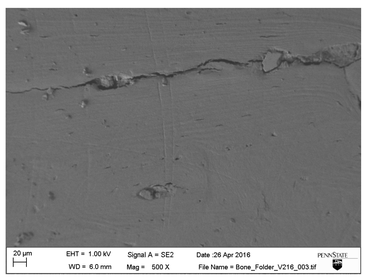


Diagram of the SEM

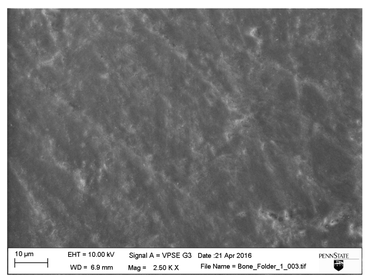
Scanning Electron Microscope in use

SCANNING ELECTRON MICROSCOPE: Small pieces of an aged bone folder that had been soaked with vegetable oil were cut to about 1 cm^2 and mounted for SEM examination; Teflon and Delrin were also examined. Below are images of the aged vegetable oil bone folder surface at increasing magnification levels: 100, 500, 2500, 10,000X. It was expected that there would be no evidence of oil residue sitting on the surface of the bone folder after cleaning and aging, and that is what was observed. Though the surface is riddled with pores, ridges, cracks and other deformities, no oil was observed in any of these possible wells. The same sample (bone, aged with vegetable oil) was then wiped with oil, cleaned with isopropyl alcohol and immediately resubmitted for analysis. In this case there is indeed oil in small pools that could transfer to paper.

Un-oiled Teflon was also examined and shows similar areas where oil could collect and thus transfer to paper.

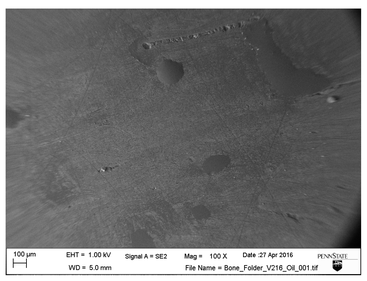


500X

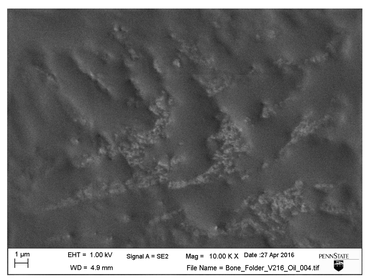


2500X

Cow Bone Folder – oiled, cleaned and aged

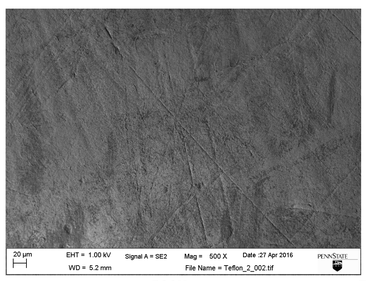


100X



10,000X

Cow Bone Folder – oiled, cleaned, aged and handled
Note dark spots are indeed pools of oil



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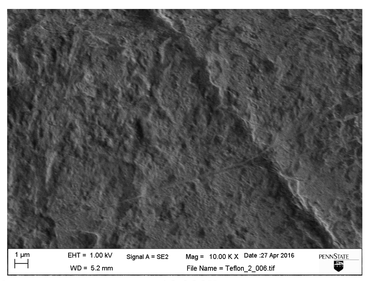
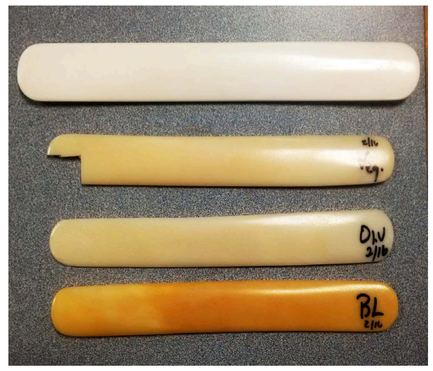


10,000X

TEFLON

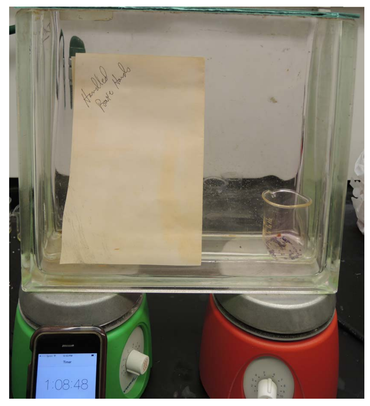
OILING A BONE FOLDER: For our study, we looked at three specific oils: Vegetable oil (100% soybean oil); 100% Olive Oil; and Boiled Linseed Oil. The sample bone folders were rubbed with the oil and then wrapped in an oil-soaked rag for a period of 48-hours. The excess oil was then washed away with soap and water. The three oiled bone folders were then aged for two months in a ~90˚F environment. This resulted in a significant color change in the sample treated with boiled linseed oil, and only a slight darkening in color of the samples treated with olive and soybean oil. An additional cow bone folder was prepared using soybean oil days prior to testing and was not placed in a heated environment. After aging, the bone folder samples, as well as the synthetic samples were then examined.

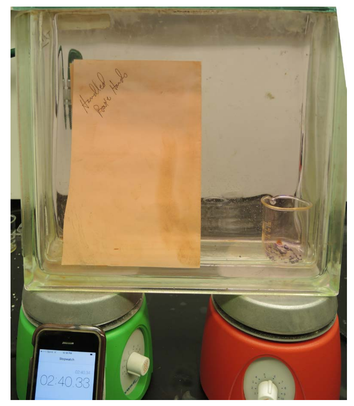


From top to bottom:
- Natural, untreated cow bone,
- Cow bone aged with vegetable oil,
- Cow bone aged with olive oil,
- Cow bone aged with boiled linseed oil.

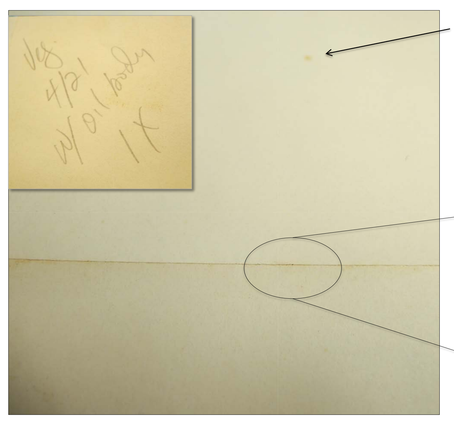
Note: The cut-off piece was used for testing.

FORENSIC SCIENCE and Iodine Fuming for latent oil residue detection: Iodine fuming is a common forensic science technique that is used to reveal fingerprints on porous and semi-porous surfaces like paper, cardboard and wood. During testing, the material under examination is enclosed in a chamber with several crystals of iodine. Applying gentle heat causes the crystals to sublime, and the violet-colored iodine vapor adheres to any fingerprint residues and turns orange. The orange stains are not long-lasting, so they must be photographed immediately. *Courtesy of: http://makezine.com/laboratory-80-revealing-latent-fing/ (accessed April 19, 2016)*



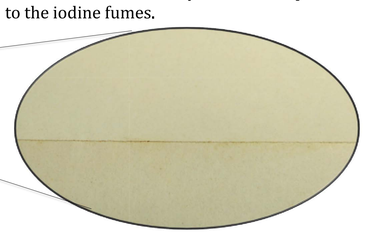


A forensic science test of paper handled with bare hands and then exposed to iodine vapors reveals that oil has been transferred. These stains will fade away upon exposure to air.



Note this enhanced oil spot, which is most likely from the papermaking machinery.

Sample paper creased with bone folder that had been oiled with vegetable oil, washed and then handled several times. Obviously, the dark line is caused by oils when exposed to the iodine fumes.



CONCLUSIONS: While we did not expect that oil would be transferred from an oiled bone folder, we do see body oil being transferred, though in extremely small amounts. Therefore, one should assume that any bone folder, even Teflon, should be washed from time-to-time to eliminate all oils.

At the same time, we learned: Burnishing of paper is the consequence of the hardness of the bone folder because it generates heat, thus ironing the paper fibers. Therefore, Teflon, due to its relative softness, is indeed a better choice to avoid polishing or burnishing the surface of paper.

One new question arises: Are particles of Teflon transferred to paper? If so, they should be of little or no concern since Teflon is inert.

One additional finding is that the iodine fuming also reveals many other oil spots that may have been deposited by the papermaking machinery.

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