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Experimentation on Alternative Uses of Bookkeeper at Northwestern University Library

INTRODUCTION

This research examined the effects of Bookkeeper on the rate of mold growth, the rate of water absorption, the discoloration of papers, and the drying of wet books. Northwestern University Library has been a client of the Bookkeeper non-aqueous deacidification product since 1994. Northwestern still turns to Bookkeeper as a non-aqueous deacidifying agent, but since 2008, the Preservation Department has conducted a variety of experiments on the secondary uses and side effects of Bookkeeper treatment. These small scale experiments have led to the observation of a number of intriguing phenomena and a few concrete results.

Bookkeeper is a product composed of a non-toxic inert liquid (perfluoroalkane), magnesium oxide particulates, and a surfactant (a polyfluoropolyether derivative). It was developed as a non-aqueous deacidifying agent to slow the rate of paper degradation and has been proven to be quite effective in achieving that goal.

MOLD GROWTH

The use of Bookkeeper appears to reduce the rate of mold growth on paper. This may be due to the overwhelming amount of magnesium interfering with optimal function of the mold's digestive enzymes, an increase in pH, which slows enzymatic activity, or other forces. The type of paper and the Bookkeeper application method seem to be significant variables.

During the early 1990s the Library of Congress specified "Blue Books," each composed of a variety of well defined papers for use in testing the Bookkeeper system's efficacy. Five papers from the Blue Books were selected for testing: Alkaline Sized, Alum Rosin Sized, Clear Spring Offset, Newsprint, and Whatman #1.

Papers were removed from a Blue Book and exposed to ambient mold spores. Some leaves were treated with Bookkeeper in a spray application and allowed to dry. Papers were placed inside of individual plastic bags with moisture to encourage mold growth. Mold grew on both treated and untreated samples, however for 3 of the 5 paper types, significantly less mold grew on samples treated with Bookkeeper. This growth pattern occurred consistently within treatment groups (figs. 1-5).

ABSORBENCY

Bookkeeper treated materials seem to absorb humidity and liquid water quicker and to a greater extent than untreated papers. Bookkeeper treated materials have been noted to have an increased wettability in the past. Despite increased absorbency, the rate of mold growth is still lower.

Absorption of Humidity

Newsprint paper samples (some sprayed with Bookkeeper) were humidified and weight changes were recorded. Papers treated with Bookkeeper appeared to absorb more water faster than untreated samples (fig. 6).

Dispersal of Liquid Water

Mohawk 60# paper had a grid pattern printed onto it using an Epson laser printer. Some papers were sprayed with Bookkeeper and allowed to dry for several days. Individual drops of water were placed on the center of the grid and observed. Water droplets placed on papers treated with Bookkeeper absorbed into the paper faster, dispersed further and left more cockling and tidelines than on untreated papers (fig. 7).

DISCOLORATION

Some of the most obvious findings relate to generally increased tidelines in many papers and overall discoloration of lignin containing papers that have been treated using Bookkeeper.

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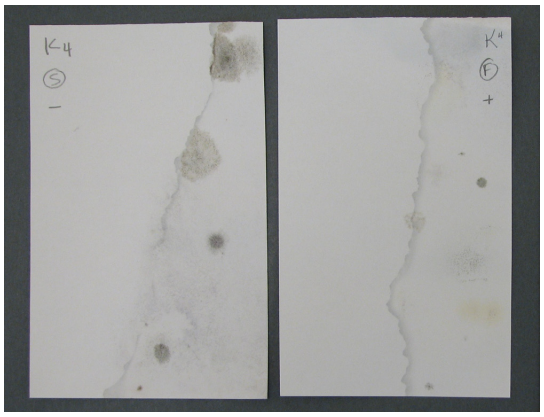

Fig. 1. Alkaline sized paper, image taken at day 19. Untreated sample on left has dramatically more visible mold than Bookkeeper treated sample on right, with similar results for all papers of this type. Both samples have distinct tidelines

Fig. 2. Alum rosin sized paper, image taken at day 19. Similar quantities of mold growth were seen on untreated sample on left and Bookkeeper treated sample on right. Growth on untreated samples of this paper type was slightly greater in quantity and much more colorful. Tidelines are slightly more pronounced on Bookkeeper treated samples

Fig. 3. Clear Spring offset paper, image taken at day 40. Similar mold growth was observed on Bookkeeper treated and untreated papers of this paper type. In this image, Bookkeeper treated sample is on the left and untreated sample on the right. Tidelines more distinct on Bookkeeper treated samples

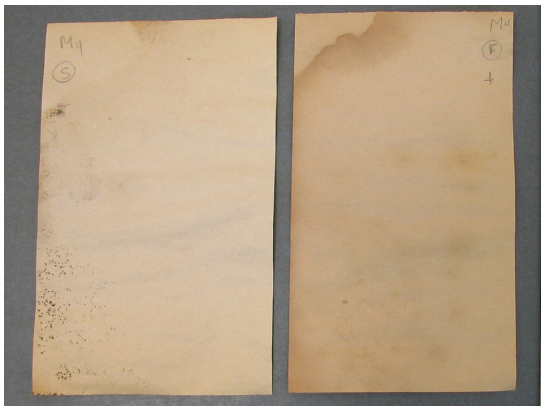

Fig. 4. Newsprint paper, image taken at day 25. Significantly more mold growth was observed on untreated samples, seen here on the left. Mold is easily visible as small black dots at left edge on untreated sample but is barely visible as an indistinct haze on Bookkeeper treated sample, seen on the right. Note distinct tideline and significant overall discoloration of Bookkeeper treated sample

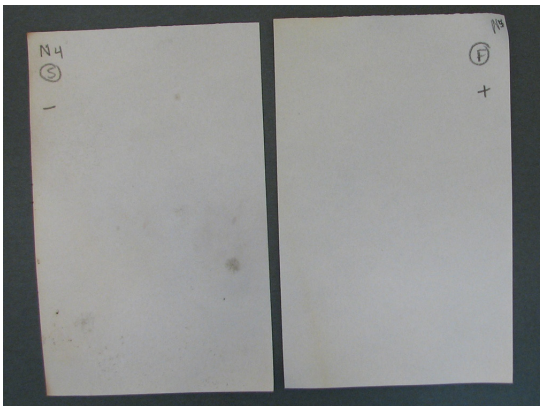

Fig. 5 Whatman #1 paper, image taken at day 45. Untreated samples, seen here on the left, had slight mold growth visible at 25 days. Treated samples, on the right, did not have visible mold growth after 45 days. Tidelines are diffused, but more colorful on treated samples

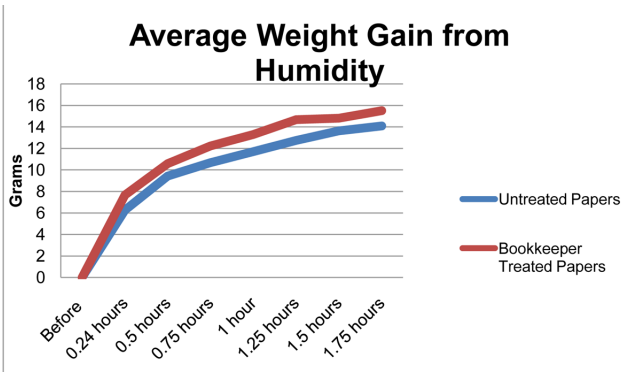

Fig. 6. Newsprint paper samples were humidified for two hours and weighed at 15-minute intervals. In a smaller comparison, two samples were humidified overnight with the sample treated with Bookkeeper ultimately gaining over 8% more weight than the untreated sample

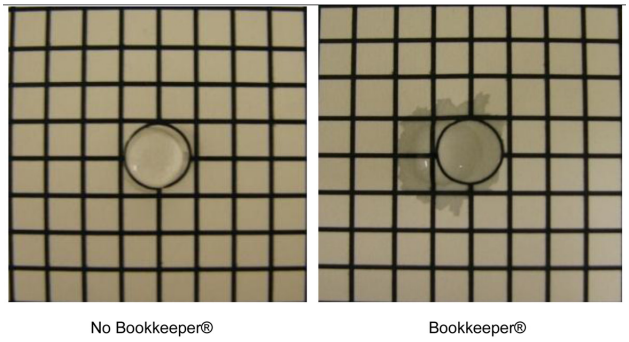

Fig. 7. Drops after about 30 minutes

Increased Tidelines

In various experiments, introduced tidelines were more pronounced on papers treated with Bookkeeper. Tidelines were immediately evident on lignin containing papers, but were evident on other papers as well. Conservators have theorized that this may be a result of localized washing, which is a risk any non-aqueous deacidification system would present to future treatments (fig. 8).

Overall Discoloration of Lignin Containing Papers

In this study, treated and untreated newsprint paper was humidified for various amounts of time. Bookkeeper treated materials darkened slightly when in a passive humidity chamber for 2 hours. Longer humidification times, simulating a disaster situation, resulted in greater discoloration. Overall discoloration was not observed in non-lignin containing papers and extensive testing has shown that Bookkeeper does prolong the useful life of newsprint (fig. 9).

DRYING OF WET BOOKS

Preliminary experimentation suggests that Bookkeeper could be part of a system for drying wet books. Wet books were submerged under a bath of Bookkeeper with sachets of the desiccant calcium chloride. It appeared as though some water from the book was transferred through the Bookkeeper to the desiccant. Books that had been under the Bookkeeper bath longer and/or had more sachet changes emerged appearing to have lost more water weight and sachets appeared to have gained roughly the same weight. This was difficult to determine, as both books and sachets emerging from the bath were wet with the very heavy Bookkeeper fluid. Although the numerous variations of this experiment consistently suggested a slight aid in drying, the chemistry is unclear and it does not appear that current methods would produce a practical method of drying. Future research could include experimentation with added surfactants to speed the process (fig. 10).

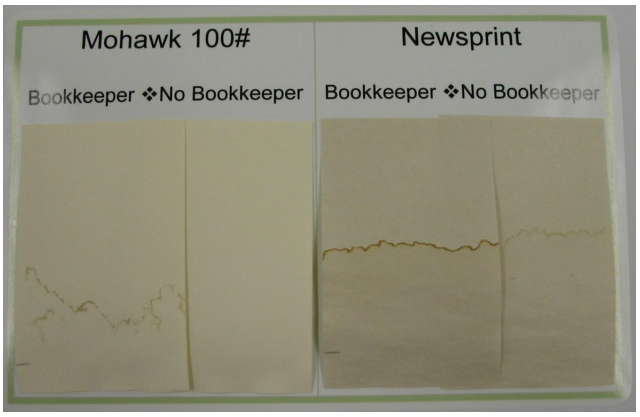

Fig. 8. Tideline comparisons

Fig. 9. Discoloration with humidification of lignin containing paper

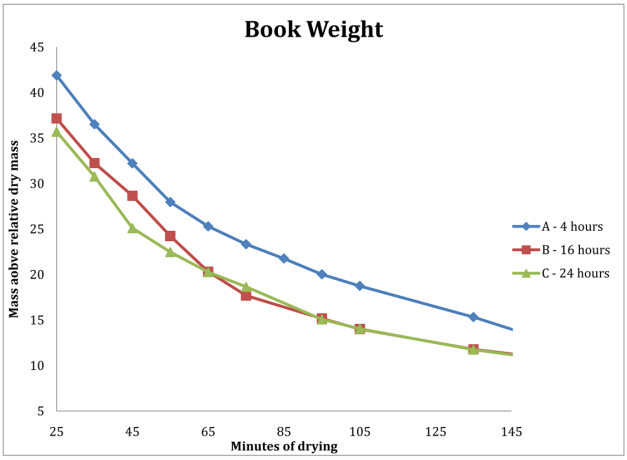

Fig. 10. This table shows the results of one test, comparing four book segments (A-D), which were submerged for different periods of time. After removal from the fluid books were weighed periodically while drying to estimate the amount of Bookkeeper fluid vs. water weight gained. Book A, which had been submerged for the least amount of time appeared to hold the most water weight. The desiccant sachet appears to have been exhausted by 16 hours, with very similar results for longer submersion times

CONCLUSIONS

- Bookkeeper seems to deter mold growth on some papers. Less mold grew on some papers, despite increased absorption of liquid water and humidity by Bookkeeper treated materials.
- Bookkeeper treated materials should be approached with additional caution when performing wet treatments, such as mending and humidification. Wetting times may be shorter and discoloration of lignin containing papers is likely to occur.
- While elevated humidity related to water disasters may be less likely to cause mold for Bookkeeper treated materials, discoloration of lignin containing papers may occur.
- Some aid in drying of wet books using Bookkeeper may be possible, but further research is needed.

ONGOING RESEARCH AND SUGGESTIONS FOR FURTHER RESEARCH

- Mold remediation—An experiment is underway to determine the efficacy of Bookkeeper at deterring additional growth of established mold. Creating adequate controls for this experiment has been problematic due to the difficulty in visually estimating mold growth, and variables introduced by the Bookkeeper spray process (drying of the sample).
- Comparison of spray vs. vat application on mold deterrence—Preliminary experimentation has suggested that both spray and vat applications of Bookkeeper appear to deter mold growth, but that the spray application of Bookkeeper appears to deter slightly more mold than the vat application. Because both the spray and vat application methods deposit significant amounts of magnesium oxide, we speculate that, if this phenomena is proven to repeatedly occur, it may be because the vat application distributes mold spores within the vat, exposing the inside of the book to spores that had been on the outside and inoculating one book with spores from adjacent books in that treatment batch. The spray application does not distribute mold spores.
- Mold or debris removal—The vat application of Bookkeeper may allow for removal of mold bodies, soot, or other loose debris from pages through the mild abrasion of the sub-micron sized magnesium oxide particles moving through the liquid. Ideally, this would gently "surface clean" the entire book, while deterring future mold growth and, of course, deacidifying it.

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