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An Audio Visual Laboratory

Revisiting Chemical Reconditioning of Cellulose Acetate Films for Improved Digital Reformatting

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ABSTRACT

Cellulose acetate motion picture films can be subject to brittleness and dimensional problems due to polymer degradation and plasticizer loss. Despite advances in film scanning technology, these problems continue to diminish digital reformatting quality or preclude reformatting at all. Chemical reconditioning, developed to de-shrink for reprinting, restores mechanical and dimensional properties and must be evaluated as a complement to scanning for optimum reformatting. In two proof-of-concept studies using six degraded 16 mm films, we observed a statistically significant improvement in objective physical (mass and thickness) and mechanical (MIT Folding Endurance) properties in two of six films following chemical reconditioning. We also carried out a production team survey of selected scanning criteria before and after chemical reconditioning to refine the survey method for a 116-film study collection.

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INTRODUCTION AND MOTIVATION

A primary motion picture medium since the early 20th century, cellulose acetate film can be subject to brittleness (Fig. 1) and loss of dimensional stability (Fig. 2) due to polymer degradation and plasticizer loss(1,2). Although contemporary film scanners using advanced gate and roller technologies have significantly improved the quality of film preservation reformatting and increased the number of films that can undergo the process, many collection items have physical deformations that preclude an acceptable scan or are too brittle to be scanned at all. These cultural artifacts are in danger of being lost.

Fig. 1. Brittle film

Formerly used to de-shrink films for reprinting, chemical reconditioning processes have been shrouded as trade secrets but are understood to have involved the deposition or intercalation of water, acetone, and sometimes camphor and phthalate vapors(3). Because of the physical and mechanical properties at least temporarily restored during deshrinking, these processes must be evaluated as a complement to contemporary film scanning to further improve the number and quality of digitally reformatted motion pictures.

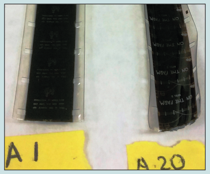

Fig. 2. Two lengths of film from the same reel. Length labeled A20 exhibits "cupping"

In this poster we present results of two proof-of-concept studies performed on a study collection of 116 films. We evaluate the impact of documented deshrinking methods on 1) objective physical and mechanical properties (mass, thickness, folding endurance) of films measured in the laboratory and 2) key scanning criteria (e.g. brittleness, shrinkage) as assessed in a blind survey of our production technicians.

MATERIALS AND METHODS

The study collection

All studies presented below make use of a study collection (116 films: fourteen 8 mm, ninety-seven 16 mm, five 35 mm; various stock types) generously donated to The MediaPreserve by the Orgone Archive. Although a complete storage history of this collection is unknown, before donation to The MediaPreserve a pronounced vinegar odor forced its owner to store it outdoors in Pittsburgh, Pennsylvania, USA for several years. Because key physical and mechanical observations must be made during the first unwind of each film in this ongoing survey, the full range of stock types and manufacturing dates represented in the collection is not yet fully known.

Chemical reconditioning and mechanical/physical properties

Selecting six film reels exhibiting mechanical and dimensional problems (all 16 mm, various stock types), we measured thickness (Fig. 3a) and mass (to 0.0001 g, Fig. 3b) of 13 cm test lengths (ten replicates) before and immediately following exposure to water, acetone, camphor, and methyl phthalate vapors (-5 in. Hg, overnight, Fig. 4). We also performed the destructive mechanical MIT Folding Endurance Test (Fig. 3c)(4) on treated samples and untreated controls.

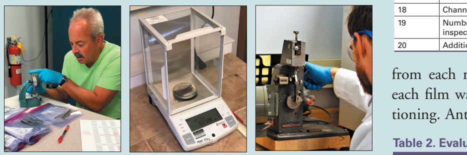

Fig. 3. (a) Thickness tester, (b) Microbalance, (c) MIT Folding Endurance tester

Fig. 4. Reconditioning apparatus

Chemical reconditioning and key reformatting properties

To refine a survey of our six-member production team (randomly assigned, single blind) on key reformatting properties before administering it on the full 116-film collection, we selected 20 criteria (Table 1) to be evaluated on the six films from the mechanical/physical studies, now less the first 8 ft. from each reel. To equalize each inspector's contribution, each film was examined by all evaluators prior to reconditioning. Anticipating different observations on the first unwind compared to the subsequent unwinds, we assigned one film to each inspector for the first evaluation. The sequence for each film is given in table 2.

Table 1. Blind inspection criteria of films for digital reformatting

Criterion	Property	Scoring
1	Record inspector, film/reel number, date and time of inspection	
2	Color	Y/N
3	Black & white	Y/N
4	Negative	Y/N
5	Positive	Y/N
6	Gauge, stock type, and date code	(Fill in)
7	Approximate film length	(Fill in)
8	Shrinkage	0-5 (0 = no apparent issue, 5 = very severe)
9	Brittleness	0-5 (0 = no apparent issue, 5 = very severe)
10	Edge wave	0-5 (0 = no apparent issue, 5 = very severe)
11	Buckling	0-5 (0 = no apparent issue, 5 = very severe)
12	Twist	0-5 (0 = no apparent issue, 5 = very severe)
13	Curling	0-5 (0 = no apparent issue, 5 = very severe)
14	Cupping	0-5 (0 = no apparent issue, 5 = very severe)
15	Vinegar odor	Y/N
16	Camphor odor	Y/N
17	Plasticizer leaching	Y/N
18	Channeling	Y/N
19	Number of breaks during inspection	(Fill in)
20	Additional condition notes	(Fill in)

Table 2. Evaluation sequence for each film

Examination	Condition
1	First unwind of film. Each examiner assigned one film to obtain equal representation of examiners in first unwind.
2-6	Prior to first reconditioning. Each film evaluated by remaining 5 examiners.
7	Examination immediately following first reconditioning (1-week exposure).
8	Examination following 1-week re-equilibration in ambient air to observe any reversion.
9	Examination immediately following a second reconditioning (1-week exposure) to assess changes in treatment efficacy.
10	Examination following a second 1-week re-equilibration in ambient air to observe any difference from examination 8.

RESULTS AND DISCUSSION

Chemical reconditioning and mechanical/physical properties

All films experienced a statistically significant mass increase during treatment (Fig. 5), which is evidence of solvent and/or plasticizer uptake. Thickness increase was statistically significant in only two films (Fig. 6), with wider data distribution in the others. This result is likely due to the adopted technique permitting inconsistent measurement of warped specimens. The same two films that gained the greatest mass and significant thickness increase also exhibited significant MIT Folding Endurance increases (Fig. 7). Given that average MIT Folding Endurance is higher for all samples following overnight treatment, and given documented reconditioning durations of weeks to months, we anticipate further enhanced folding endurance with additional exposure.

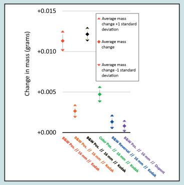

Fig. 5. Mass change (grams) for films as marked

Chemical reconditioning and key reformatting properties

Seven criteria in the survey, numbers 8-14 in table 1, are scored with six-level Likert items with 0 being most conducive to scanning and 5 the least. Figure 8 gives the average of all criteria 8-14 responses for all films (hollow black line) for the examinations in table 2 completed to date. From this amalgamation, no appreciable difference is evident between the first and the next five examinations of the untreated films. (Note that samples were previously taken from each reel.) Also the first examination of treated films, 7, does not show appreciable improvement from previous. Figure 9 gives the average score of the seven criteria for each examination. It reveals adverse properties more evident (buckling and shrinkage) in the collection than others (brittleness and twist) but is again less revealing of the films' response to conditioning. A trend toward poorer properties following equilibration to ambient conditions (examinations 8 and 10) is apparent in figures 8 and 9 but drawn from few films and should be probed with more data.

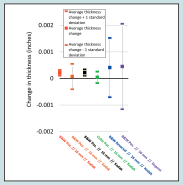

Fig. 6. Thickness change (inches) for films as marked

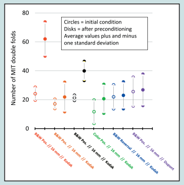

Fig. 7. Number of MIT double folds for untreated and treated films as marked

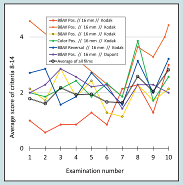

Fig. 8. Composite scores of key scanning criteria for six films in examinations given in table 2: 1-6 before reconditioning, 7 & 9 immediately following reconditioning, 8 & 10 following re-equilibration to ambient conditions

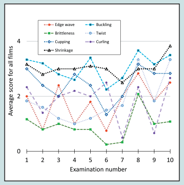

Fig. 9. Average score of specific scanning criteria in examinations given in table 2.

CONCLUSIONS AND FUTURE WORK

Following overnight conditioning of test lengths (ten replicates for six films):

- We observed a statistically significant mass increase in all samples, establishing solvent and/or plasticizer uptake.
- We observed a significant increase in both MIT Folding Endurance and thickness in two of six samples. Given documented reconditioning periods of weeks to months, we anticipate significant physical and mechanical effects of reconditioning in collections.

A blind survey of six films consistently scored some in better overall condition than others, and certain properties adverse to scanning more prevalent than others, but it has not yet revealed appreciable changes due to chemical reconditioning.

In future work, we will expand the survey to the full 116 film collection, adding the objective criterion of shrinkage by means of a K. L. Shrinkage Gauge.

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Acknowledgments

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