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RESTORATION OF MOLDED VIDEOTAPES: RESEARCH ON VACUUM-FREEZE-DRYING OF WATER DAMAGED VIDEOTAPES

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ABSTRACT

Videotapes are very susceptible to damage from increased relative humidity levels, which can cause hydrolysis and lead to mold growth. The restoration of molded videotapes is time consuming and demands certain safety precautions. Furthermore, the delicate nature of videotape and its compact winding make it very difficult to successfully treat large stocks of wet magnetic tapes. To reduce such elaborate manual treatments, a research project to test vacuum-freeze-drying of wet tapes was carried out. In the field of paper conservation, vacuum-freeze-drying is already an established standard but it has not been recommended in the literature for the recovery of water-damaged tapes.

This research was carried out by a team at the University of the Arts, Bern, Switzerland, in cooperation with private partners and was financed by a grant of the Swiss National Science Foundation.

The paper presents early results of this research. During testing, different video formats (both analog and digital) were soaked with water and were vacuum-freeze-dried under different conditions. For the scientific evaluation of the material effects on the tapes, the samples were examined with the help of light microscopy, infrared spectroscopy and scanning electron microscopy. The focus of the research project was to investigate changes of the video signal caused by vacuum-freeze-drying procedures.

INTRODUCTION

This article is based on the author's experiences acquired in private practice as a conservator for video as well as on the results of a research project carried out at the University of the Arts Bern at the Department of Conservation and Restoration of Modern Materials and Media. The first part of the paper focuses on mold-infested videotapes and their treatment. The second part is dedicated to recommendations to prevent such mold growth in the wake of flooding.

MOLD ON VIDEOTAPES

As a general rule, microorganisms grow under conditions of increased relative humidity and higher temperatures accelerate growth in most cases. Like almost all organic materials, components of magnetic videotapes can also become a culture medium for microorganisms and under the appropriate climatic conditions will serve as substrates (fig. 1). Following initial water damage, moisture often remains for long periods within the dense winding of the tape pack and the close casing of the cassette. The inside of the cassette shell additionally conceals a number of notches and hollows, which hinder the evaporation of the water. The interior of the housing can thus provide a damp microclimate which advances the growth of microorganisms.

Though magnetic tapes are equipped with anti-fungal agents (Sullivan 1998, 458), mold can nevertheless develop under the described ideal conditions. Usually dust serves as an initial carrier of contaminants. In most cases it also does serve as a substrate. Accordingly, mold

Fig. 1. VHS cassette with heavy mold infestation.

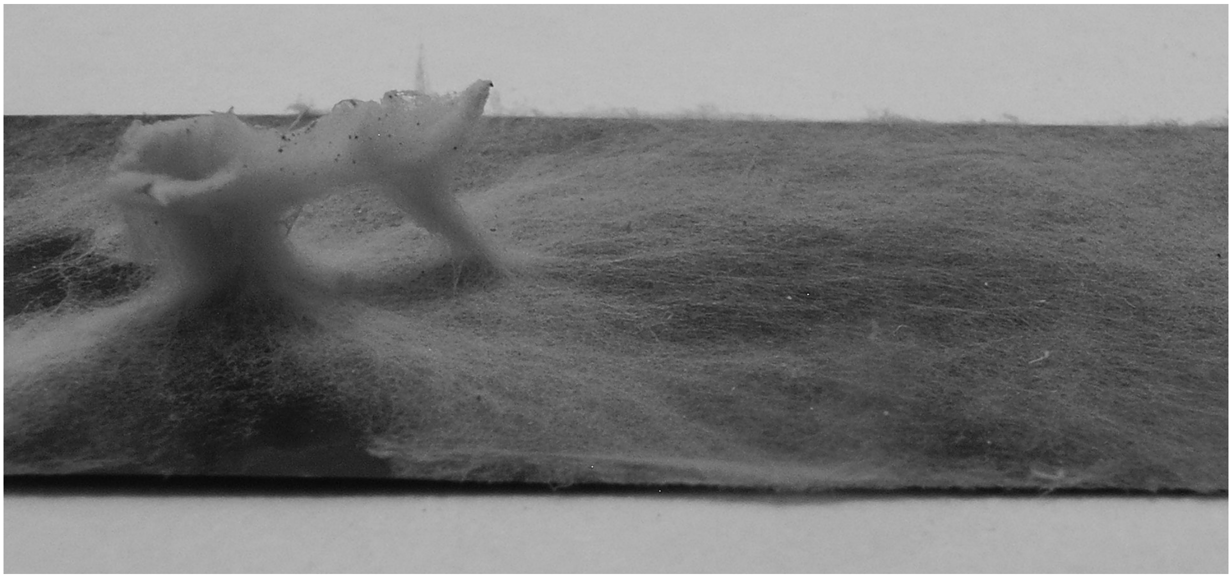

Fig. 2. VHS tape, unwound. Tape width is ½-in. The mold infestation on this tape is superficial only.

first starts to grow on the surface of a magnetic tape (fig. 2), but it can invade deeper into the tape and the tape pack if the material components provide a favorable substrate for a particular kind of fungus. Figure 3 shows a VHS tape, of which the binder (a copolymer of polyester-polyurethane) has been consumed by fungus.

Imminent hazards

It is important to immediately identify mold infestation. If contamination with microorganisms is not detected the effects are manifold:

- First—and most importantly—it can lead to serious health problems for people in direct contact with the spores of a molded tape and its toxic byproducts of decomposition (Meier and Petersen 2006, 39)
- The second hazard is the destruction of the tape as the infestation can lead to sticking of the tape winding. Such tapes are likely to tear when played. Tapes may also show embrittlement, which inevitably leads to an intensified abrasion of the surface of the video heads during play.
- Third is the hazard of contamination of the videotape playback equipment (VCR) and the succeeding tapes played in the same deck. Playing infected tapes leads to an infestation with mold spores of the equipment and the succeeding cassettes played in the same VCR. This will consequently lead to a spreading of the problem, especially under favorable damp and warm conditions. Therefore, playing molded tapes and cassettes should be avoided on equipment that may be used with other tapes.

CLEANING OF MOLD-INFESTED VIDEOTAPES

When the author was recently charged with cleaning a group of VHS tapes infested by microorganisms (figs. 1, 2), wet cleaning had to be considered. The tapes were unwound in meter-long sections and pulled through a bath of distilled water with a small amount of isopropyl alcohol that served as a wetting agent. Dirt and mold were then wiped off manually with microfiber cloths that had previously been sterilized. In the next step, the tapes were dried manually again with microfiber cloths. After a few minutes of air drying the tapes could then be spooled back onto cleaned or new cassettes. The tapes were digitized at the end of the cleaning process.

Manual wet cleaning has proven to be very efficient, but also very labor intensive and time consuming. Polyester-polyurethane, serving as a binder, is likely to undergo hydrolytic decomposition. These decomposition products are responsible for what is known as sticky-tape syndrome (Van Bogart 1995, 300; Bertram and Cuddihy 1982, 993). Despite the danger of hydrolytic decomposition, manual wet cleaning was chosen in order to additionally avoid mechanical stress and static charge. As some of the tapes were showing signs of embrittelment, they were already sensitive to handling. Wetting the tapes lead to temporary plasticization, which allowed for a less invasive and more efficient cleaning method which also made the tapes play better. The above-mentioned effects and the efficient removal of the mold through the chosen wet cleaning procedure justified the likely side-effect of accelerated hydrolysis. For future storage, all cassettes are kept in sealed bags with a desiccant.

The results of wet cleaning the mold-infested tapes was very satisfactory, but the process was also complex and time consuming. This practical experience—and the knowledge of published reports of the effects of mold damage—show clearly that it is extremely important to prevent the growth of mold immediately after water damage. This is even more pertinent considering the safety measures that are necessary for treating such tapes. The question arose, how could mold infestation be prevented beforehand? Could vacuum-freeze-drying, known as a standard method in paper conservation, be effective with magnetic tapes?

FIRST ATTEMPTS IN VACUUM-FREEZE-DRYING

Guidelines for the recovery and treatment of water-damaged magnetic tapes generally advise against vacuum-freeze-drying. Early experiments in vacuum-freeze-drying were conducted in 1992 with ¼-inch open reel audiotapes (Copeland and Ward 1992). The authors immersed half of each test reel into water, then after freezing the tapes they were freeze-dried. When playing back the tapes they observed a loss of signal.

Until now, practically all published literature on safeguarding water-damaged tapes has spoken strongly against vacuum-freeze-drying methods. In addition, it is assumed that a deviation of 8°C can lead to exudations on the tape surface (Schüller 1993, 2008). In 2007, the author and Guido Voser, paper conservator and head of docuSAVE, carried out first attempts in vacuum-freeze-

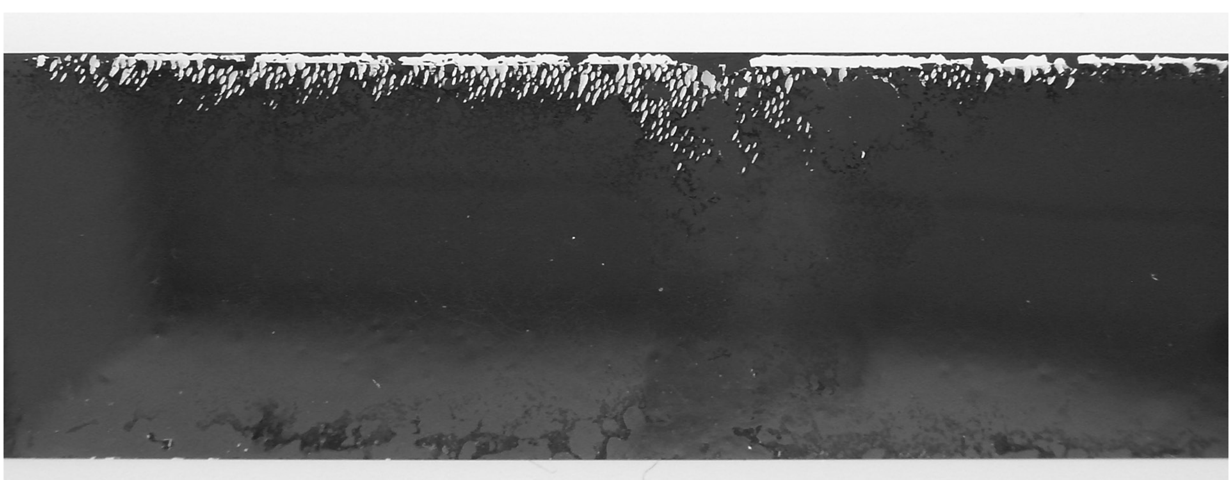

Fig. 3. VHS tape, unwound. Tape width is ½-in. Detail of tape shown in figure 1. In this example the fungus invaded deeper into the tape pack and consumed the binder of the magnetic tape, visible as holes on the upper edge.

Fig. 4. Video stills of a DVCAM tape from sample group A, synchronized and combined in one picture. Bottom right is the oscillographic representation of the video image in the background (color bars). The left half of the oscilloscope represents the first field of the video signal, the right half represents the second field. In this case an attenuation of the second field can be seen clearly. The duration of this error was one field only, which was hardly visible in the video image (color bars).

drying videotapes. As these first results were promising, a broader research project was initiated. The research was carried out by a team at the University of the Arts Bern in cooperation with private partners and was financed by a grant of the Swiss National Science Foundation within the DO REsearch (DORE) funding program.

VACUUM-FREEZE-DRYING AS FIRST AID MEASURE?

What are the expected advantages of vacuum-freeze-drying water damaged magnetic tapes? Besides the prevention of mold growth, one of the most important advantages is a gain in time: Rescuing and cleaning can be planned with less time pressure. A selection of the cassettes to be salvaged and cleaned does not need to be conducted immediately on site, which usually happens during a stressful emergency. In addition, cleaning and digitization can be carried out in a step-by-step process and the procedures of rescuing and treating water-damaged collections of diverse archive material can be simplified. Affected magnetic tapes can thus be integrated into the same rescue workflow as paper documents, for which vacuum-freeze-drying is already an approved method for the salvage of large quantities of water damaged paper.

The procedures described below were conducted on a statistically relevant number of test samples. Three standard cassette formats of different technologies and manufacturers were selected: Betacam SP, VHS, and DVCAM. Analog and digital formats, such as Metal Particle and

Metal Evaporated tapes, were included. To allow for reproducibility of the test results, all experiments were conducted exclusively on new material.

The study considered the potential for damage caused by the vacuum-freeze-drying procedure, notably exudations on the tape surface and the possible loss of signal.

Preparation of the test samples

A test signal was recorded onto all of the test tapes at the beginning of the study. Evaluation of the video signal provided the basis for assessing the potential damage caused by the vacuum-freeze-drying process. All recording machines were equipped with new and specially modified head drums that allowed output of a video signal and an RF-signal, the latter being an indicator for the signal-to-noise-ratio (Capelo and Brenner 1998, 363). The analysis of the RF-signal with the help of an oscilloscope allows evaluating signal attenuations and breakdowns, which can't be visualized by the conventional video signal displayed on a cathode ray tube monitor (fig. 4).

During testing, the samples were exposed to different wet and dry conditions, which were documented in detail. In the first test run, the entire cassettes and cut-out tape samples of the three formats were divided into the sample groups described in table 1.

The first series of wet treatments was carried out with distilled water and later with distilled water with a measured addition of mud and fine gravel at a water temperature of 21°C (room temperature) for 40 hours. The water, which had filled the inside of the cassette shells, was then manually shaken out. Afterwards, the cassettes were put in a refrigerator with their lids down at -18°C for 10 days. The frozen samples were then placed into a custom-made vacuum-freeze-drying chamber, developed by Guido Voser and his team. The vacuum-freeze-drying process ended after 16 days. All samples designated to be air-dried were kept at room temperature (21°C). The relative humidity was maintained at roughly 50%RH with dehumidifiers. After a few days of air-drying, it became clear that some of the cassettes still held water in the notches of the housing. To prevent mold growth, the cassette shells were opened to promote the drying process. Contrary to the initial plan, the preparation of samples in soiled water was eventually dismissed as it turned out to be too complex of a model for evaluating the results. All results described hereafter refer exclusively to wet treatment in distilled water.

RESULTS

For the evaluation of the signal quality, the differently treated cassettes were digitized, which is standard procedure. During the digitization process, the oscillographic representation of the head signals was taped

Sample Group	Wet Treatment	Frozen	Dried
A	Distilled water	—	Air-dried
B	Soiled water	—	Air-dried
C	Distilled water	Frozen	Vacuum-freeze-dried
D	Soiled water	Frozen	Vacuum-freeze-dried
E	—	Frozen	Vacuum-freeze-dried
F (Control)	—	—	—

Table 1. Overview of differently treated sample groups of the first test cycle. Each sample group consists of seven samples of each manufacturer and format.

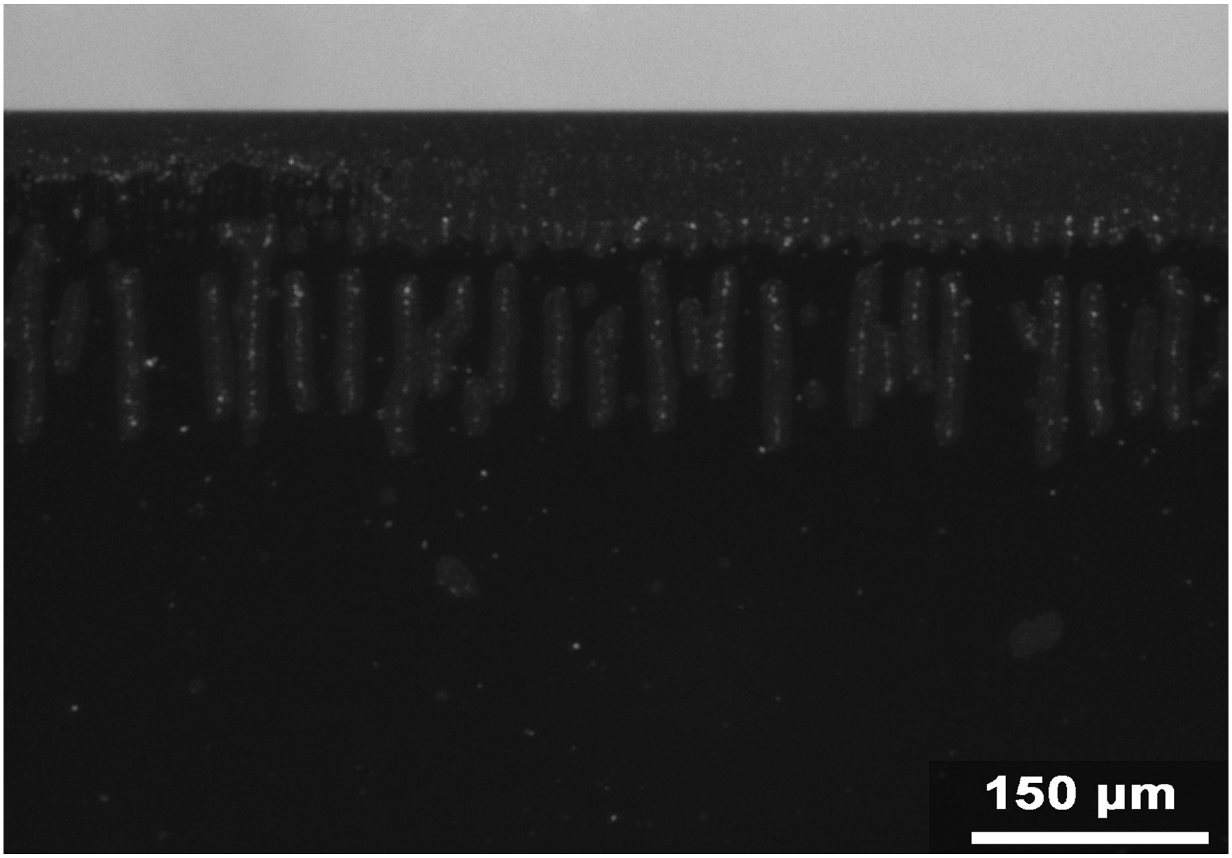

Fig. 5. Microscopic view of a DVCAM tape showing corrosion phenomena running perpendicular to the tape edges.

with the aid of a video camera. The two video images were synchronized and the visible periods with signal attenuation were counted (fig. 4). It became apparent that the area of prominent damages strongly correlated with the most exposed and vulnerable part of the tape: the section under the cassette lid. Where the tape pack was tightly wrapped and showed no popped strands, the tape was less likely to be affected by water.

The extents of the signal quality's impairment of air-dried tapes and vacuum-freeze-dried tapes were comparable, supporting the vacuum-freeze-drying procedures.

In addition to the evaluation of the video signals, the surfaces of all tapes were examined. In the earlier test procedures carried out in 2007, Betacam SP tapes showed evidence of exudation products on the surface after having been vacuum freeze-dried. In the more recently carried out test series, this phenomenon was absent in all tests. Unfortunately, the origin and age of the tapes used in 2007 cannot be determined precisely, because the group consisted of unknown recycled tapes.

Screening the samples with the stereo-microscope, all test samples showed some sort of corrosion phenomena (fig. 5). This was observed on Betacam SP tapes as well as on DVCAM tapes. This was surprising, as Betacam SP tape has a Metal Particle coating while DVCAM is a so-called Metal Evaporated tape. Theses two formats differ significantly in their structure and the properties of their coating. Tapes of both formats from the control sample group E (which were frozen and vacuum-freeze-dried without wet treatment) did not show this phenomena. Therefore, vacuum-freeze drying as a procedure could not have been the cause for this change, but seems to play a role as an intensifying factor when the results are compared against sample groups A and C (wet treatment in distilled water and air dried vs. frozen and vacuum-freeze-dried). One indication might be the fact that both types of tape are produced in large sheets and then cut. One possible explanation for the observed corrosion could be that water penetrates more easily into the tape structure along the cut edges. An important finding in this context is the fact that the corrosion phenomena appears to not have had a substantial impact on the playback qualities of the videotapes.

All treated tapes are currently stored on a long-term basis under normal archive conditions so that future playback tests can be carried out. This allows for an assessment of possible long-term damages through the observed corrosion phenomena.

The image quality seemed to be unaffected by the corrosion, but some of the wet-treated tapes were very embrittled, regardless of either air or freeze-drying. This fact poses a severe problem for the playback equipment and calls for further testing.

CONCLUSION

Under the test conditions of this study, vacuum-freeze-drying shows a clear potential as a recovery solution for water damaged videotapes. Signal loss was observed only on the first few centimeters under the tape lid. With ideal archival storage conditions, tapes would presumably be wound back for storage and would be equipped with recorded reference signals during the first minute or even longer. In these cases, the loss of a reference signal would be an acceptable loss given the circumstances of extensive water damage.

It must be noted that the described results were produced within a simplified testing model. Future research could consider other factors such as contaminated water. The absence of exudations on the tape's surface was unexpected and surprising. One possible explanation may be that these exudations are related to the formation and migration of degradation products. Furthermore, future research should be conducted on aged test samples and on other video formats, like Digital Betacam, which are widely used in archives.

Future testing by the author will include wet treatment of samples at different temperatures, to determine if the corrosion phenomena can be ascribed to water temperature. Before changes are made to the prevailing recommendations for salvaging water-damaged magnetic tapes, additional research should be carried out and the findings verified.

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FURTHER READING

ISO. 2012. Imaging materials—magnetic tape—care and handling practices for extended usage, 18933-2012, second edition. Geneva: International Organization for Standardization.

SOURCES OF MATERIALS

Betacam SP tapes:
- Fuji M321 SP
- Maxell B-10M BQ
- Sony BCT-10MA

DVCAM tapes:
- Fuji DV131
- Sony PDVM-12N

VHS tape:
- Emtec Broadcast Master E15

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