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Gamma Radiation for Preservation: A Novel Approach to Disinfect VHS Tapes in Historical Archives

Nagai[a*], M. L. E.; Dias[b], D. B.; Vasquez[b], P.

[a] Department of History - Faculty of Philosophy, Letters, and Human Sciences - University of São Paulo, 05508-000, São Paulo, São Paulo, Brazil.
[b] Nuclear and Energy Research Institute, IPEN-CNEN/SP/ Brazil

*Correspondence: malunagai@usp.br

Abstract: Preserving historical artifacts, such as VHS tapes, in archival collections presents significant challenges, particularly in environments conducive to mold contamination. Inadequate control of temperature and relative humidity can promote mold growth, endangering the structural and informational integrity of these cultural assets. This study explores the application of gamma radiation treatment for the disinfection of mold-contaminated VHS tapes stored in historical archives. Utilizing the Multipurpose Gamma Irradiation Facility at the Institute of Energy and Nuclear Research (IPEN) in São Paulo, Brazil, we investigated the efficacy of gamma radiation in eradicating mold while preserving the tapes' mechanical properties and visual appearance. Despite the long-standing use of gamma ionization for decontamination since the 1960s, this research is novel in its focus on VHS tape preservation. Tensile tests and visual inspections were conducted on control, biodeteriorated, and gamma-irradiated samples. Results showed that gamma irradiation significantly improved tensile strength and strain in mold-contaminated tapes, with no observable changes in their visual appearance. This study contributes to the development of innovative preservation techniques, addressing the unique challenges posed by environmental factors in the storage of historical materials and underscoring the potential of gamma radiation as a dual-function method for disinfection and mechanical reinforcement.

Keywords: gamma radiation, cultural heritage, historical VHS tapes, disinfection.

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Radiação Gama para Preservação: uma nova abordagem para desinfecção de fitas VHS em arquivos históricos

Resumo: A preservação de artefatos culturais, como fitas VHS, presentes em arquivos históricos, apresenta desafios significativos, especialmente quando há exposição em ambientes propícios à contaminação por mofo. O controle inadequado da temperatura e da umidade relativa do ar pode promover o crescimento de fungos nos materiais, colocando em risco a integridade estrutural e informacional das fitas VHS. Este estudo explora a aplicação do tratamento por radiação gama para a desinfecção de fitas VHS de arquivos históricos contaminadas por fungos. Utilizando a instalação do Irradiador Multipropósito de Cobalto-60 do Instituto de Pesquisas Energéticas e Nucleares (IPEN) em São Paulo, Brasil, investigamos a eficácia da radiação gama na erradicação do fungo, preservando as propriedades mecânicas e a aparência visual das imagens contidas nas fitas. Apesar do uso estabelecido da ionização gama para descontaminação desde a década de 1960, esta pesquisa é inédita em seu foco na preservação de fitas VHS. Testes de tração e inspeções visuais foram realizados em amostras controle, biodeterioradas e irradiadas com raios gama. Os resultados mostraram que a irradiação gama melhorou significativamente a resistência à tração das fitas contaminadas por fungo e manteve a sua aparência visual e das imagens. Este estudo contribui para o desenvolvimento de técnicas inovadoras de preservação, abordando os desafios impostos por fatores ambientais no armazenamento de materiais históricos e destacando o potencial da radiação gama como método de dupla função para desinfecção e reforço mecânico.

Palavras-chave: radiação gama, patrimônio cultural, fitas VHS históricas, desinfecção.

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1. INTRODUCTION

Preserving historical artifacts, such as VHS tapes, in archival collections poses unique challenges, especially when faced with environmental conditions that foster mold contamination. The inadequate control of temperature and relative humidity can lead to the growth of mold, threatening the integrity of these valuable cultural assets [1,2]. This study explores the application of gamma radiation treatment as an effective method for the disinfection of VHS tapes contaminated with mold in historical archives.

In particular, we focus on the utilization of gamma radiation at the Nuclear and Energy Research Institute (IPEN), São Paulo, Brazil. The Multipurpose Gamma Irradiation Facility at IPEN has been at the forefront of employing gamma radiation for the decontamination of historical and cultural artifacts [3,4]. The research investigates the efficacy of gamma radiation in eradicating mold from VHS tapes while preserving their structural and informational integrity.

Despite the widespread use of gamma ionization for decontamination purposes since the 1970s [5], this study is unprecedented in the context of VHS tape preservation. This study contributes to the broader understanding of innovative preservation techniques, addressing the unique challenges posed by environmental factors in the storage of historical materials.

1.1. Composition and Vulnerability of VHS Tapes

VHS (Video Home System) tapes, introduced by JVC in the 1970s [6], revolutionized home video recording and playback. These tapes consist of a magnetic tape housed within a plastic cassette. The magnetic tape itself is composed of several layers [7]:

1. **Base Film:** Typically made of polyethylene terephthalate (PET), providing the primary structural support.

2. **Magnetic Layer:** Consisting of ferromagnetic particles (usually iron oxide or chromium dioxide) embedded in a binder, this layer is responsible for storing the video and audio signals.
3. **Binder Layer:** A polymer matrix that holds the magnetic particles together and adheres them to the base film.
4. **Back Coating:** Applied to the reverse side of the tape to reduce friction and static electricity during playback and winding.

VHS tapes are particularly susceptible to mold attacks due to several factors:

- **Organic Materials:** The binder and magnetic layers contain organic compounds that can serve as nutrients for mold spores.
- **Environmental Conditions:** High humidity and fluctuating temperatures can create ideal conditions for mold growth. VHS tapes stored in such environments are prone to contamination.
- **Aging:** Over time, the materials in VHS tapes can degrade, making them more vulnerable to mold and other forms of deterioration.

Mold contamination can lead to physical damage, such as pitting and etching of the magnetic layer, resulting in loss of recorded content and compromised playback quality. Effective preservation methods are crucial to protect these cultural artifacts from further degradation.

In this study, we evaluate the use of gamma radiation to disinfect mold-contaminated VHS tapes, preserving their historical and informational value while maintaining their physical integrity.

2. MATERIALS AND METHODS

The gamma radiation treatment utilizing the The Multipurpose Gamma Irradiation Facility at IPEN, São Paulo, Brazil, involved exposing mold-contaminated **three samples** of VHS tapes to a standard dose of 10 kGy, a commonly accepted level for the disinfection of cultural heritage materials [4]. Polyethylene terephthalate (PET), the primary structural support of VHS tapes, is known to tolerate doses up to 25 kGy without significant degradation, as commonly applied for sterilization and decontamination processes [8,9]. This provides a safe margin for the selected dose of 10 kGy in this study, ensuring effective treatment while preserving the material's integrity. The irradiation process was conducted at a controlled rate of 5 $kGy.h^{-1}$ to ensure an effective treatment.

Tensile tests were applied to samples of historic VHS tapes. The tests were carried out using a Universal Testing Machine (Instron 5567), measuring the parameters in accordance with ASTM D 882 [10]. This comprehensive approach allowed the comparison of mechanical properties under different conditions, thus evaluating the effectiveness of gamma irradiation in preserving the structural integrity of mold-contaminated VHS tapes. Tensile strength was calculated as the maximum stress endured by the sample during the test, while tensile strain was determined by measuring the percentage elongation at the point of maximum stress. Young's modulus was determined by calculating the slope of the linear portion of the stress-strain curve.

In addition to the mechanical analysis, the evaluation extended to the visual aspects of the VHS tapes. Images from a copy of VHS tape were captured both before and after gamma radiation exposure using a VCR (video cassette recorder) connected to a television. This setup allowed for a detailed inspection of the playback quality and any potential visual changes on the screen. A comprehensive visual inspection included an assessment for the presence of mold, stains and any other visible changes to the tape

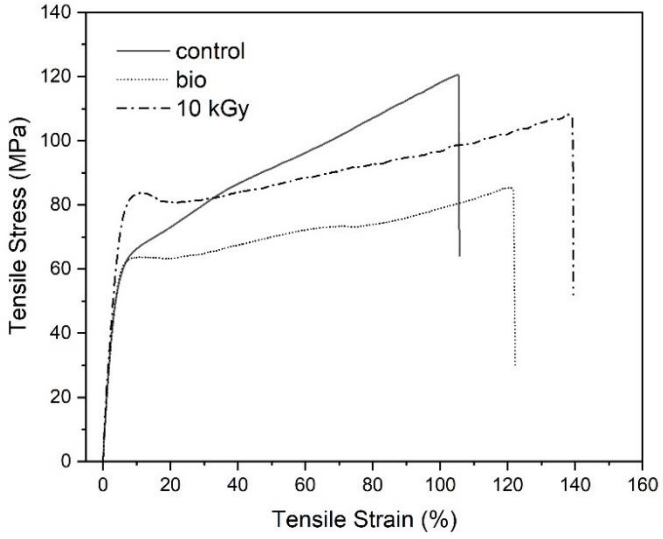
surface. Special attention was given to preserving the information encoded on the tapes and ensuring that the visual quality remained intact.

The combination of visual evaluation and mechanical analysis provided a holistic understanding of the impact of gamma radiation on the VHS tapes. The assessment of images served as a qualitative measure to complement the quantitative data obtained from the mechanical tests, offering insights into the overall preservation and appearance of the historical materials after the disinfection process. The comparison of pre- and post-irradiation images aided in determining the efficacy of gamma radiation in preserving both the structural and visual integrity of the VHS tapes in historical archives.

3. RESULTS AND DISCUSSIONS

Tensile test results provide valuable information about the mechanical properties of three samples of historic VHS tapes, in different states of conservation and after gamma ray disinfection treatment. Figure 1 shows the results of tensile tests on a historical sample in good condition (control), a sample with signs of mold (biodeteriorated) and a sample with signs of mold irradiated with γ rays at a dose of 10 kGy.

Figure 1: Stress versus Strain graph of VHS tape samples



The introduction of a biodeteriorated sample, without irradiation treatment, provides critical insight into the impact of gamma irradiation compared to both mold-contaminated and uncontaminated VHS tapes. The control sample exhibited lower tensile strain compared to the biodeteriorated sample, likely due to the loss of structural integrity in the latter caused by mold, which makes the material more elastic but weaker. For the γ-irradiated sample, the increased tensile strain suggests that irradiation not only disinfects but also improves flexibility. This improvement may result from molecular rearrangements or cross-linking induced by gamma radiation, which enhance mechanical performance without compromising the material's integrity.

Table 1 presents the key parameters derived from the tensile tests, including tensile stress, tensile strain and Young's Modulus, for control, biodeteriorated and irradiated samples. Comparison of these values allows a comprehensive assessment of the changes induced by gamma radiation in the mechanical performance of the material.

Table 1 : Tensile test data for VHS tape control, biodeteriorated and γ-irradiated (10 kGy) sample

SAMPLE	TENSILE STRESS (MPa)	TENSILE STRAIN (%)	YOUNG'S MODULUS (MPa)
Control	121.96	103.96	1250.72
biodeteriorated	64.46	131.38	1235.94
10 kGy	88.20	136.96	1489.85

Tensile stress and strain data provide valuable insights into the mechanical properties of the VHS tape samples. The control sample exhibited a tensile stress of 121.96 MPa and a strain of 103.96%, reflecting its original strength and elasticity. The biodeteriorated sample, affected by mold, showed a marked reduction in tensile stress to 64.46 MPa, alongside an increase in strain to 131.38%, indicating a weakened yet more elastic material due to mold-induced degradation. Following gamma irradiation, the tensile stress improved to 88.20 MPa, and the strain increased further to 136.96%, demonstrating enhanced mechanical properties post-treatment, with improved strength and flexibility.

Young's modulus values further elucidate changes in material stiffness. The control sample displayed a modulus of 1250.72 MPa, representing the inherent rigidity of the VHS tape in good condition. The biodeteriorated sample exhibited a slightly reduced modulus of 1235.94 MPa, reflecting minor stiffness loss due to mold degradation. Notably, the γ-irradiated sample demonstrated an increased modulus of 1489.85 MPa, suggesting that gamma irradiation not only mitigates the adverse effects of mold but also enhances the material's rigidity.

In summary, gamma irradiation not only disinfects mold-contaminated VHS tapes but also enhances their mechanical properties, as evidenced by the increased Young's modulus and tensile stress in the treated samples. These findings highlight the potential of gamma radiation processing as a dual-purpose method, effectively disinfecting mold-contaminated VHS tapes and positively influencing their mechanical properties. This dual benefit highlights the potential of gamma radiation as an effective preservation technique for historical artifacts.

This mechanical enhancement aligns with visual inspection results, where no observable alterations in the appearance of VHS tapes post-gamma irradiation were noted. The combined mechanical and visual analyses contribute to the overall discussion, supporting gamma radiation as a viable preservation strategy for historical artifacts.

In addition to mechanical analysis, a visual inspection involved capturing images of the historical VHS tape before and after th e gamma radiation treatment with 10 kGy. By capturing the images through playback, we could directly compare the pre- and post-irradiation visual output, ensuring that no secondary effects from the gamma radiation impacted the recorded content. Notably, no discernible differences were observed between pre- and post-treatment images, indicating the absence of visual alterations resulting from secondary effects of irradiation and confirming that the gamma irradiation process did not degrade the visual quality of the tapes, as shown in Figure 2.

Figure 2: Images obtained from VHS tapes before (above) and after (below) processing with gamma radiation at an absorbed dose of 10 kGy

This visual assessment is crucial as it supports the mechanical analysis findings by providing evidence that the gamma radiation treatment did not cause any detectable damage or degradation to the physical appearance of the tapes. The absence of visual changes suggests that the gamma irradiation process is gentle on the VHS tapes, ensuring that their informational content remains intact and the aesthetic value of these historical artifacts is preserved.

Maintaining the visual integrity of tapes is particularly significant for archival purposes, where the functional and aesthetic qualities of materials are essential. The lack of visible damage post-irradiation implies that gamma radiation can be employed as a reliable preservation method, ensuring that the tapes remain in a condition suitable for future playback and historical reference.

Furthermore, the combination of mechanical and visual assessments provides a comprehensive assessment of the impact of gamma irradiation, reinforcing its potential as

an effective, non-destructive method for disinfecting and preserving mold-contaminated VHS tapes. This dual approach highlights the overall benefits of gamma radiation in the conservation of audiovisual heritage, addressing both the structural and visual aspects crucial for long-term archival preservation.

4. CONCLUSIONS

In conclusion, our investigation into the application of gamma radiation for the disinfection of mold-contaminated VHS tapes in historical archives has yielded promising outcomes. the tensile test results, particularly with the inclusion of the biodeteriorated sample, reinforce the positive outcomes of gamma irradiation in both disinfection and mechanical reinforcement. This dual benefit positions gamma radiation as a promising preservation technique for mold-contaminated cultural heritage materials. Future research should delve deeper into the specific mechanisms underlying these effects, further refining gamma radiation protocols to obtain safe results in the preservation of cultural heritage.

The absence of discernible alterations in the visual appearance of the VHS tape post-treatment underscores the non-destructive nature of gamma radiation. This finding aligns with the preservation of both mechanical and visual integrity, affirming gamma radiation as an effective method for disinfecting mold-contaminated artifacts without inducing adverse secondary effects.

Our study contributes to the evolving field of cultural heritage preservation, highlighting the potential of gamma radiation to safeguard historical materials. The comprehensive analysis of mechanical and visual aspects provides a robust foundation for future preservation strategies.

Looking forward, continued research should delve into refining gamma radiation applications, exploring adaptability to diverse cultural artifacts, and addressing potential long-

term effects. Collaborative efforts between preservation experts, scientists, and archivists remain essential for advancing holistic approaches to safeguarding our historical heritage.

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