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1st International Symposium on Gamma Ionization: technology for preservation of cultural heritage

Radiation Technology Center - CETER
IPEN, São Paulo, Brazil
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Abstract Book

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Foreword

The Nuclear and Energy Research Institute–IPEN mainly through the Multipurpose Gamma Irradiation Facility located inside the University of São Paulo – USP campus started a strong interaction program with conservation and preservation institutions and the conservation community and because of this interaction, several cases of success in the application of the technique were achieved.

The aim of the 1st International Symposium on Gamma Ionization: technology for preservation of cultural heritage was to bring together the preservation institutions and the conservation community that has benefited or used the ionizing radiation for preservation. It was an opportunity to exchange views and experiences in the fields of disinfection by ionizing radiation of tangible biodegradable constitutive materials.

It is important to acknowledge the efforts of all people who contribute to technical quality of the Symposium program and proceedings publication as well authors, referee, and technical committee. They have all made their best and worked hard for the Symposium success. We would like to thank the invited speaker Laurent Cortella from ARC-Nucléart CEA – France who very kindly accepted our request and his lectures will provide a new vigor and greater brilliance to the event.

We also express our gratitude to all entities companies and foment agencies that have had some form of participation, either direct or indirect, for the success of the Symposium, in particular to the International Agency of Atomic Energy – IAEA for the support through projects and publications and to the “Ivani e Jorge Yunes” Collection for the support during all organization.

The Symposium Organizing Committee wants to recognize that success of this meeting truly lies on the people attending the event.

Pablo A.S. Vasquez

Chair

Content

1st International Symposium on Gamma Ionization: technology for preservation of cultural heritage
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Gamma Irradiation: a Tool for Remedial Conservation
- *Biocide Treatment of Cultural Heritage Artefacts* -

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Keywords: gamma radiation; cultural heritage conservation; biocide treatment.

Abstract

Gamma irradiation can be used as a process for remedial conservation of cultural heritage. Simple irradiation at adapted doses can stop biodegradation. It is also applied to trigger radio-curing of resin for consolidation of porous material-based artefact that need it. In ARC-Nucléart, Grenoble, France, these two processes have been continuously used on a very wide variety artefacts irradiation of cultural heritage items from almost 50 years.

Gamma Insect Eradication of Wooden Polychrome Sculpture
(Angels and Apostles, 17th c., Le Pègue, France). © C. Albino, P. Avavian – ARC-Nucléart

Biocidal treatment is the most common use of gamma irradiation. Its application to cultural heritage conservation is the subject of this first lecture. A dose of 500 Gy is a threshold required for the elimination of insect by deterministic effects whatever the species and stage (egg, larvae, pupa or adult insect). After such a dose, larvae or adult insect can survive some weeks but cannot transform to next stage nor reproduce. Increasing the dose will have the effect of killing them more quickly. Fungicidal effect is not deterministic but statistical. The more the dose is high, the less is the percentage of survival fungi. Doses between 5 to 10 kGy are currently used, reducing the active population by a factor 1000 to more than 10^{10}, depending of the species. The idea is not to reach an absolute sterilization but to reduce the worst contamination to an acceptable level, the one that can be encountered in a said “healthy” storage.
Those doses have to be compared to the ones that can lead to potential unlikely side effects, often at least one order of magnitude higher. Experience has shown that the technique can be applied safely on a very large range of material. The only true contraindication concerns

transparent material that can darken or be coloured by irradiation even at low doses. However, special attention must be paid when unexperienced material are treated. It is sometime necessary to make new studies to verify that the behaviour of new material under irradiation is not a problem.
Mastering of the process is quiet simple. One can easily understand that the main parameter to be controlled is the dose. It can be calculated and measured with a precision sufficient to ensure the expected biological effect without taking risks of unwanted side effects.
In ARC-Nucléart, many thousands of cubic meters have been treated since the seventies, mainly for insect eradication. It included furniture, wooden sculpture, ethnographic artefacts, musical instruments, taxidermy specimen, modern art, etc. Mummies, among which the one of Ramses the second, have been also treated. A frozen baby mammoth is another illustration of what can be treated by this method (gamma irradiation does not lead to any thermal effect).

The mommy of Ramses the second was treated in 1977 by gamma radiation to arrest fungi contamination. © M Langlois – ARC-Nucléart.

In France, treatment of paper-based material was not practiced for many years because of a noticed depolymerisation effect, even if it was not connected to any macroscopic degradation of the properties of paper. However, after a disaster occurred in French National Archive, it appears necessary to implement this technique that was the only one able to treat huge volumes. It also gives opportunity to make studies to verify that some non-standard archival support materials (tracing paper, argentic photography, architect blueprint) were compatible with it.
Finally, gamma irradiation appears as a very interesting tool for biocidal remedial treatment for cultural heritage artefacts, according to the conservation issues.

The use of gamma radiation to the disinfestation of the Afro Brazil Museum

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Keywords: cultural collection, museum, disinfestation, gamma radiation.

Abstract

The Afro Brazil Museum is an institution linked to the Secretariat of Culture and Creative Economy of the State of São Paulo. It has a museum, archival and bibliographic collection that addresses Brazilian culture through the Afro and Afro Brazilian matrix. This collection is made up of works whose composition is predominantly organic matter such as wood, vegetable fibers and leather.

Among the three-dimensional objects that make up the collection are masks and sculptures produced by cultural groups from various African countries with various functions: ceremonial, devotion, celebration, thanksgiving, etc. Some bring a latent infestation that, in the museum, due to natural climate, humidity and temperature are relatively high, presenting favorable conditions for the development of xylophagous insects, insects in general, fungi and other microorganisms.

The Afro Brazil Museum annually receives a very large audience – 171.441 (2018) general visitors and 53.286 (2018) students, who circulate among the works of the collection. This is the main reason why we opted for the use of gamma radiation in the disinfestation of infested works, since they do not have toxic residues capable of affecting or contaminating the visiting public and the professionals who work directly with these collections.

The museum's professionals have been following the research that is being developed internationally and, here in Brazil at the Nuclear and Energy Research Institute - IPEN regarding the gamma radiation doses that are safe to be applied in the cultural collections to eliminate the contaminating organisms and suitable for do not cause any damage to the components of each object treated.

Another aspect that was taken into consideration when choosing gamma radiation was that we could deal with a considerable number of objects (large and small) at the same time and in a short time. All these aspects were fundamental to consider the use of gamma radiation as an important mechanism in the preservation of our collection.

Gamma radiation for document disinfection – receipt of Rubem Valentim collection

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Keywords: donation, Rubem Valentim Institute, MASP, gamma radiation, cobalt-60, irradiation, disinfection, fungus, vinegar syndrome, cellulose, triacetate, document, photography, slide, manuscript, books.

Abstract

Studies on the application of gamma rays for disinfection of cultural goods in Brazil can be found since 1994. Maria Guiomar Carneiro Tomazello brings, in her thesis, an in-depth study on fungal disinfection on cellulose support, comparing several authors, studying doses of radiation for disinfection at all stages of life of biological degrading agents (TOMAZELLO, 1994).
In this case study, documents received in a donation containing various genres and supports were irradiated by the Multipurpose Gamma Irradiation Facility of the Radiation Technology Center - CETER/IPEN - CNEN mainly aiming at the disinfection of documents affected by fungi and bacteria. The Museu de Arte de São Paulo Assis Chateaubriand received a donation from the Rubem Valentim Institute of approximately 10.000 documents by the artist of the same name composed of personal documents, certificates, travel books, manuscripts, typed texts, newspapers, books, enlargements, slides, negatives, three-dimensional objects, finally, the most varied genres and supports in the most varied states of conservation.
After a diagnosis, fungi, dirt and animal droppings were identified throughout the collection. The documentation had been for many years in the city of Rio de Janeiro and its boxes bore "Skylight" inscriptions, which made us think that this documentation could have received a lot of light and been subjected to high temperature and humidity levels considering this characteristic coastal climate (Figures 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6).
We found weak and brittle fungal-infected papers and flexible supports composed of fungal-affected cellulose acetate and already in the process of "vinegar syndrome" (a process due to the hydrolysis of the ester bond of degrading material, which regenerates acetic acid, causing a characteristic vinegar odor). All of this documentation still had to be sorted, identified and handled by the MASP Research Center staff before it could be offered to researchers.
There was an imminent concern about how we would receive this donation directly, quickly and safely to staff and researchers who would contact it.
An aggravating factor was the time, since the transfer of the material to the Museum had to be done quickly and safely, and there was no possibility of performing the treatment and packaging before it reached the Museum.
Thus, we began a brief inventory, which supported us in finding the most effective disinfection measure, and most correct for our receiving purpose.
We sought, on the basis of theses and articles, protocols that would help us make the best decision for effective, safe and brief treatment, since conventional disinfection treatments would

be ruled out due to the length of treatment and the impossibility of training a team for such treatment in such a short time.
According to research conducted between 1994 and 2019, we were able to safely confirm recommended doses to treat biodeterioration in cellulosic (paper) based materials and suitable for the case of cellulose triacetate polymeric support films.
As a determining factor for the choice of conducting gamma ray disinfection, we used the protocol developed with the help of the IPEN present in Maria Luiza Nagai's dissertation, which addressed, among other issues, gamma radiation applied to flexible supports. In it, we find the safe radiation dose to be used for materials composed of cellulose triacetate between 6 kGy to 10 kGy, without alteration or modification of the main properties of the constituent materials (NAGAI, 2019). To assure us as to the safe dose to be used only for cellulose and the structural changes of the paper support materials, we used Fernanda Mokdessi Auada's thesis as a source, "for the evaluation of the conservation state of the papers showed that the irradiation process with gamma rays in the studied dose range, taking the 16 kGy dose as a limit, did not induce structural changes in the paper-based materials studied in this work" (AUADA, 2018).
The material, following the safety protocols, was submitted to the IPEN pre-calculated doses for each support material and received absorbed doses from 8 kGy to 10 kGy. What we got from the results were fungal and bacterial-free documents, safe to handle and ready to be mechanically sanitized and archivally treated, as we can see in the Figures 2.1, 2.2, 3, 4.1 e 4.2.


Figure 1.1 – Silver based prints infected by fungi with areas of emulsion loss.

Figure1.2 – Detailof the rusty boxes with the inscription "Clarabóia".

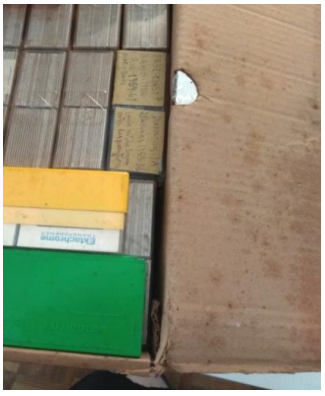
Figure1.3 - Boxes containing fungi and lots of dirty diapositives.


Figure1.4 – Weak and brittle newspaper.

Figure1.5 – Various genres and types of media.


Figure1.6 - Boxes separated by support type, ready to be taken to IPEN.

Figure 2.1 – Colored diapositive infected by fungi on the emulsion part.

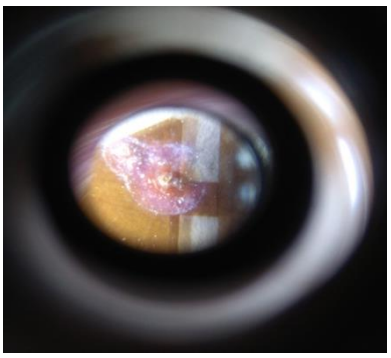

Figure 2.2 - Fungus-free material with only one emulsion gelatin color altered by the metabolic action of microorganisms (60X).

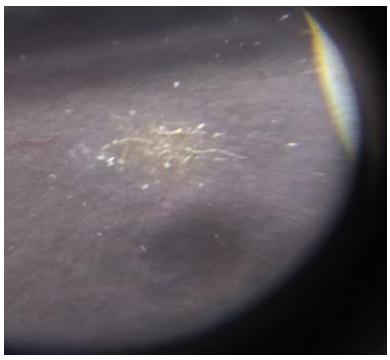

Figure 3 - Colored diapositive with areas of loss after radiation. Enzymes released by fungi soften, dissolve gelatin and cause areas of emulsion loss (60X).

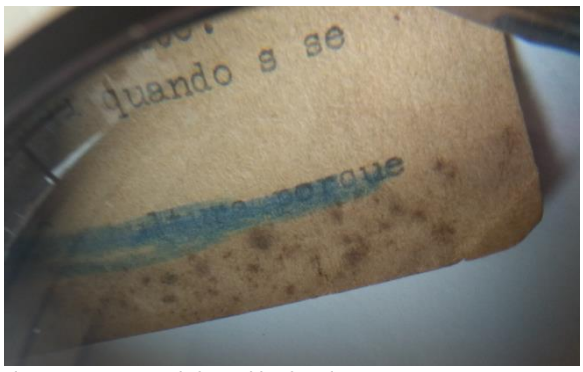

Figure 4.1 - Paper infected by fungi.

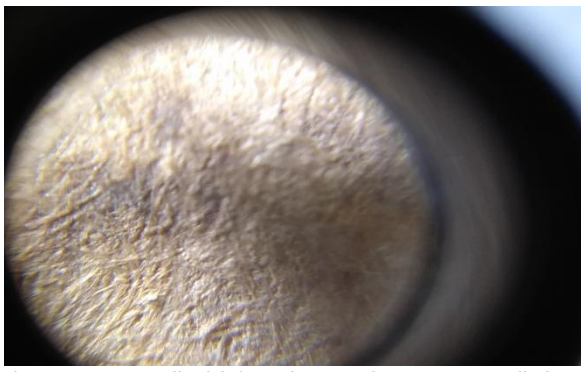

Figure 4.2 - Detail of infected area after gamma radiation, bringing only stains to paper fibers (60X).

Thus, we conclude that the gamma-ray disinfection method proved to be adequate for our needs of receiving and incorporating the documentation into the MASP Research Center collection, as well as giving us the security of not affecting the physical characteristics of the documents beyond your natural aging process.
Gamma radiation, according to the case study, is understood as an effective tool for the treatment of cultural collections and can be another measure applied to the preservation of the documents of Museums, Libraries and Research Centers.

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The use of ionizing radiation for the conservation of collections of wooden furniture at the Museu Paulista of USP

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Keywords: conservation, cultural heritage irradiation, wood furniture, disinfesting xylophagous insects

Abstract

The Museu Paulista has a collection of important documents and objects for understanding the formation of Brazilian society with a special focus on the History of São Paulo. Studying, researching, promoting, teaching and preserving are some of the activities that the museum develops. Routine work with the collection requires preventive conservation care in which objects are evaluated for their material state. In this assessment, all objects undergo visual inspection periodically and possible changes are noted. In this task, the collection objects that have damage due to biodeterioration are prioritized for separation of the environment in technical reserve and treatment. Treatment can be preventive or curative. In the case of damage by xylophagous insects, the evaluation is given as an active, suspected or inactive infestation. Each case is totally specific and must produce an action, which can be regarding its efficiency, preventive and/or curative, and regarding its nature, chemical, biological or physical.
In this study, an ionization treatment action is presented in the Multipurpose Gamma Irradiation Facility of the Radiation Technology Center at the Nuclear and Energy Research Institute - IPEN of a set of 42 items of furniture and wooden objects from the collection. Such objects had active or suspected infestation by xylophagous insects.
The ionization treatment made it possible to disinfect large objects, such as disassembled beds, showcases and wooden cabinets, and smaller objects such as household items, wooden spoons and wooden boxes for food storage. Among the items treated are the bed that belonged to the Marquesa de Santos dated 1890, made in France in walnut wood and gilded bronze and furniture belonging to Santos Dumont, also manufactured in France in walnut wood. The irradiation doses were determined by the CETER-IPEN team for historical heritage and disinfestation of xylophagous insects on wood. The objects were placed in the irradiation chamber in their transport packaging in wooden and cardboard boxes, and pre-packed in glassine paper and bubble wrap without interfering with the treatment. After the procedure, the treated items were returned to the new technical reserve for preventive conservation and restoration care. The efficiency, time and safety that the ionization method provides as a curative treatment in xylophage infestations become an important procedure for the conservation and preservation of mobile cultural heritage.

Gamma Ionization for the Preservation of the *Conjunto das Químicas* Library Collection /USP partnership with CETER/IPEN – case study

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Keywords: preservation of the collection; conservation; gamma radiation disinfestation.

Abstract

The work describes the stages of the process of disinfestation of the bibliographic collection through the Multipurpose Gamma Irradiation Facility at the Center for Radiation Technology (CETER) of the Nuclear and Energy Research Institute (IPEN). To report the gamma irradiation treatment in the infested works of the collections of books and journals of the Library and Documentation Division of the Set of Chemists of the University of São Paulo. The works were identified following the protocol of the CETER - IPEN. The irradiation treatment was performed at the Cobalt-60 Multipurpose Irradiation Facility of the CETER/IPEN. Gamma rays penetrate the material and reach the cells of insects and microorganisms, destroying DNA and causing cell death. The cobalt-60 is immersed in a tank with water at 7 meters depth where the water works as an insulator, so that the environment inside the machine is not exposed to inadequate doses of radiation in the disinfestation process. The process does not affect the physical-chemical properties of the treated material, that is, it does not alter the integrity of the works in their original form, and does not cause damage or risks to the technicians and users who would directly handle the collection. The material may only be submitted to the gamma ray irradiation process once. The Library's bibliographic collection constitutes public heritage. Efforts must be made to keep it preserved, which guarantees the availability of access to and use of the information and its transmission to future generations.

Peculiar artwork and treatment with Gamma Ionization

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Keywords: irradiation of artworks; contemporary art; large dimensions; diversity of materials; gamma radiation works of various materials; eradication of biological activity.

Abstract

Conservare is a private Art Conservation and Restoration studio specializes in Contemporary Art. Among the collections we serve, we often encounter problems with biological activity in contemporary works that feature a great diversity of materials (often several materials composing the same artwork), fragile techniques, irregular shapes with difficult or inaccessible areas, and of large artworks.
When we identify the presence of biological activity we consider the extent of contamination, types of material that compose the artwork, dimensions and the time we have to treat it. Sometimes the works are on loan for exhibitions and the issue of time is vital for the artwork to be exposed.
This was the case of an artwork by artist Luiz Zerbini, for which we made the conservation report before transportation, as it would be loaned to the Cartier Foundation in Paris. The diagnosis was widespread fungal attack. In partnership with IPEN, we were able to treat this artwork with gamma radiation in a quick and efficient way. But there was an important detail, this was a large painting and would not go through the Radiator's door. Therefore, we removed the painting from the stretcher and wrapped it in a properly sized tube so that it could pass through the treatment and proceed to its loan destination safely.
Also, in the case of artworks where disassembly is possible and there are parts that should not be irradiated, as they would suffer alterations, for example, glass and porcelain, we can remove these parts, and treat the others by gamma ionization.
Here we present some case studies of artworks that were irradiated at IPEN, with Dr. Pablo Vasquez assistance, with the following types and combination of materials:
1) Wood frame and Glass*, Voile Fabric and Marker Pen (* in agreement with the owner of the artwork, we chose not to remove the glass before irradiation for protection of the artwork - it was replaced after irradiation because it darkened as it was foreseen);
2) Wood, EVA, Metal, Plastic Fins (for collar), transparent polyester film and Electrical Circuit;
3) Leather, Wood, Natural Feathers, Fabrics, Stuffed Wolf's Paw;
4) Scrap: Wood, Plastic, Paper and Adhesives;
5) Copper and Rubber Tubes;
6) Acrylic Ink on Cotton Mat;
7) Wooden and Glass Box * with Plush Dolls; (* In agreement with the owner of the work, we chose not to remove the glass before irradiation to protect the work - it was replaced after irradiation because it darkened as expected);
8) Synthetic rope crochet;

9) Metal typewriters and paper;
10) Plastic adhesives glued on wooden board;
11) Book Hardcover and Electronic Board;
12) Collage with Paper and Paraffin on Wood;
13) Metal and Paraffin
14) Wool Hats, Fabric Ties, Aluminum Cups & Holders, Ceramic Plates (Plates were removed and did not undergo Irradiation)
15) Open and stitched soccer balls in a fabric;
16) Plastic, Wood and Foam;
17) Wood and Vinyl Adhesive;
18) Graphite on PVC;
19) Brick Powder;
20) Nanquin on Hardboard;
21) Wood and Metal Screen with Acrylic Wool;

In these cases of studies that we subjected to gamma radiation, we were able to solve the problem of biological attack, without the need to use chemicals that could decharacterize, leave residues or cause any damage to the artworks, ensuring that inaccessible parts of the artworks have also been treated and no active contamination hotspots remain.

The result obtained was excellent, both in terms of disinfestation and in maintaining the original characteristics of all works.

An important note we make to our customers is that this is a curative and non-preventive process, so the work must return to a suitable environment with temperature and humidity control and free from contamination. In addition, we also warn that we cannot expose the artworks to gamma radiation numerous times, because the radiation is cumulative and there is a safe radiation limit that can be delivered, so this is not an unlimited resource.

Preventive Conservation - Collection of the Palaces of the Government of São Paulo

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Keywords: preventive conservation, restoration, treatment, xylophagous insects, Irradiation.

Abstract

As an introduction to the lecture, some important points were presented in relation to preventive conservation and restoration of material goods; the importance of training in looking at problems that may be occurring with the works in their exhibition and guarding location; the concepts of preventive conservation and restoration where preventive conservation contemplates every attitude taken with the purpose of protecting the work of art from deteriorating factors and that of restoration as a direct action in the works aiming at its stabilization and respecting the integrity and historicity of the material.
Highlights include deteriorating factors such as climatic factors with changes in temperature and relative humidity, environmental factors such as pollutants, biological factors such as termite pest infestations, borers, rodents, moths and microorganisms and human factors.
The Artistic-Cultural Collection of the Palaces of the Government of the State of São Paulo presents about 3.500 pieces. In partnership with IPEN for approximately 8 years, we treated several pieces among furniture, paintings, sculptures, prints and books using the Multipurpose Gamma Irradiation Facility.
The logistics of the work adopted by the team begins with the detection of problems, continues with the preparation of technical reports containing all information on techniques, supports and materials of the piece, monitoring of the packaging of the works by a specialized company, monitoring of the process in the multi-purpose gamma irradiation facility and exit from IPEN works.
The information about the works in the technical reports is of paramount importance so that they can be irradiated with the required dosage and time. The ionizing radiation in our case for the treatment of infestations by xylophagous insects and microorganisms. After treatment with ionizing radiation, the work proceeds to restoration and or sanitization.
One of the most important factors in the treatment of works with radiation is safety. The works that had infestations by microorganisms or xylophagous insects after the radiation could be handled, sanitized, restored and packaged without danger of contamination for the conservator, restorer and for the works themselves, since there is no residual effect product on the pieces.

Gamma ionization application in the Ivani and Jorge Yunes Collection - CIJY

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Keywords: preventive conservation, private collections, disinfection, irradiation.

Abstract

In October 2017, almost two months after the death of businessman Jorge Yunes, work began on his artistic and bibliographic collection, and on his small but essential documentary archive. The initiative, led by Mrs. Ivani Yunes and Beatriz Yunes Guarita, included the formation of a multidisciplinary team responsible for the physical reorganization of the collections, their cataloging and digitalization, conservation and restoration procedures, research and extraversion. The works combined the museological parameters defined by the ICOM - International Council of Museums (UNESCO) - with the expertise of academics and specialists in the various CIJY nuclei and typologies. In addition to these contributions, the Curator Council supports actions for physical and digital preservation, and the dissemination of works and knowledge through institutional partnerships, exhibitions, projects with universities, symposia, colloquia and seminars. The efforts were extended not only to the collections of Fine Arts, Applied Arts and Library, but also to the historical archive, with the retrieval of information on acquisition, certification and loan processes. To ensure the physical preservation of the works, an acclimatized technical reserve was built, the restoration laboratory was set up and parameters and procedures were established for the conservation of the various types and supports. As a private collection kept in a residence still inhabited, with environments used in daily life, the conservation of the works requires the combination of personal and affective choices with museum standards. Anyway, one of the first actions was the location of the items that required conservation and / or restoration because they were in poor condition due to the intrinsic fragility of the support, damage, attack by fungi and insects, or other causes. The procedures for prevention, diagnosis, isolation, disinfestation and physical preservation of the works began. These actions were able to count, as of March 2018, with the partnership of IPEN - Institute of Energy and Nuclear Research -, so that works from different origins, dates, locations, supports, dimensions and formats could be subjected to gamma radiation. Typologies such as furniture, painting, sculpture, drawings, prints, photographs, publications, documents, textiles and musical instruments were subjected to gamma rays in the Multipurpose Gamma Irradiation Facility at IPEN. Special attention was given to works with glassy components, whether in attachments such as frames, or in their composition, including precious stones, glass eyes or clothing adornments from pieces of the Neapolitan nativity scene. In most of these cases, it was decided to remove the vitreous components or to use alternative disinfection processes. The documents that tell the history of CIJY were also subjected to irradiation, allowing the handling, scanning and searching of receipts, certificates, notes, information about

origin and previous owners. Special attention is given to works assigned to exhibitions and external events, such as the Brazilian academic paintings exhibited in “Artist's work - Image and self-image (1826-1929)” (Pinacoteca do Estado, São Paulo, and Museu Nacional de Belas Artes, Rio, 2018-2019); publications borrowed for “Partial hallucinations: school exhibition with modern masterpieces from Brazil and the Center Pompidou” (Instituto Tomie Ohtake, São Paulo, 2018), “Retrospective of Ismael Nery - Female and male (Museum of Modern Art, São Paulo, 2018), “Poetry and Visual Arts (Galeria Superfície, São Paulo, 2018),“ AI5 50 years - not finished yet ”(Instituto Tomie Ohtake, São Paulo, 2018); the African pieces in “Africa, mother of all us” (Museu Oscar Niemeyer, Curitiba, 2019-2020) and “The other Africa” (Museu de Arte Sacra, São Paulo, 2020). Once the main biological damage agents (fungi, termites and borers) have been eliminated, the great permanent challenge is to prevent reinfestation - mainly because it is a collection preserved in a living, inhabited residence, where ideal conditions of isolation and preservation cannot always be achieved. maintained all the time. Prevention actions include periodic inspections, quarantine and observation rooms and, above all, a team that is always attentive and ready for immediate decisions. Prevention processes are essential to minimize the need for a second - at the limit, a third radiation. The scientific and technological processes provided by the partnership with IPEN have supported the physical preservation of different items in the Ivani and Jorge Yunes Collection. The variety of items submitted to gamma radiation has formed an interesting field of study of the effects of cobalt-60 on different supports, materials and typologies. The joint work generates not only new information, but also support for initiatives such as the 1st International Symposium on Gamma Ionization: Technology for the preservation of collections, where new applications of gamma radiation can be shared with an increasingly broad audience.

Effect of ionizing radiation on the color of featherwork

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Keywords: featherwork; ethnographic objects; organic objects conservation; colorimetry; cultural heritage irradiation.

Abstract

Featherwork collections are usually stored and managed by ethnographic museums. Even though the featherwork manufacturing is still practiced by the indigenous communities, the offer of raw material and the contact with the surrounding society ended up reducing the production scale of such objects.
Consequently, the preservation of the culture heritage is very important, particularly in museums. Biodegradation can affect featherworks mainly by xylophagous insects and moths' action. The tropical Brazilian weather contributes to the contamination and proliferation of insects and fungi making the preservation conditions difficult. The use of gamma radiation for the disinfection of cultural heritage objects and archived materials has shown to be a safe process and an excellent alternative to traditional methods usually involving high persistent and toxic chemical pesticides. In this work are presented the preliminary results of the ionizing radiation effects on the color and morphological properties of a featherwork from the Museum of Archeology and Ethnology of the University of São Paulo (MAE/USP). Samples of feathers were selected from the artifact and irradiated with gamma rays at the Multipurpose Gamma Irradiation Facility at IPEN, applying absorbed doses between 0.5 kGy to 200 kGy. Samples were firstly chosen according to feather colors, photographed and analyzed using colorimetry with CIELAB 1976 color space scale and scanning electron microscopy (SEM), just after and 48 hours after the irradiation process. The results shown had no significant changes on color and morphological properties within the disinfection absorbed dose range applied.

Effect of ionizing radiation on the color of botanical collections – exsiccata

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Keywords: exsiccates conservation and preservation, botanical collections ionizing irradiation, herbarium collection conservation.

Abstract

Conservation and preservation methods are essential to maintain the wholeness of botanical collections specially for dried herbarium specimens also known as exsiccates, usually referring to a set of identified specimens belonging to taxa and distributed among all herbaria around the world. These vegetal materials are subjected to fungal attack and insect pests threatening their entirety. In recent years, disinfection by ionizing radiation has become an effective strategy to preserve cultural heritage objects and archived materials with excellent results. In this work, the effects on color properties of exsiccates samples irradiated with gamma radiation from Co-60 with different absorbed doses were studied. The botanical pressed and dehydrated samples – exsiccates – were selected from the Dom Bento José Pickel Herbarium (SPSF), located at São Paulo (Brazil). Two exsiccate samples were selected: SPSF-4021 and SPSF-08821. These samples come from Asteraceae and Solanaceae family and were collected in 1946 and 1984, respectively. Families of selected botanical collections are very susceptible to biodegradation. The irradiation was performed at the Multipurpose Gamma Irradiation Facility at IPEN applying absorbed doses of 1 kGy, 6 kGy and 10 kGy. The selected ranged dose promotes insect disinfestation and fungal disinfection. Results were analyzed using colorimetry with CIELAB color space scale. Scanning electron microscopy were performed to analyze surface topography and elemental structure modifications by ionizing radiation and characterize the non-irradiated (0 kGy) and the effective disinfected (10 kGy) exsiccata samples. The results revealed no significant changes on colorimetric morphological properties of then irradiated samples. The color changes between the non-irradiated samples and the irradiated sample at the high absorbed dose are perceptible, but acceptable considering the adopted scale. The microscopy images of the non-irradiated and 10 kGy irradiated samples did not show significant differences in the topographic morphology of the exsiccata samples. The results obtained corroborate the studies of the application of gamma radiation to preserve materials of cellulosic origin. Subsequently and for continuity of this research, other samples will be analyzed.

Ionizing radiation for the preservation and conservation of photographic and cinematographic films

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Keywords: cultural heritage preservation; gamma irradiation; radiation processing; photographic films; cinematographic films; disinfection.

Abstract

The Nuclear and Energy research Institute – IPEN-CNEN/SP through the Multipurpose Gamma Irradiation Facility has treated several bibliographical collections of Sao Paulo University-USP for disinfestation and disinfection of contaminated materials with insects and fungi. In this sense, gamma radiation from cobalt-60 is an excellent alternative tool to the traditional preservation process mainly because the biocidal action. Disinfection using gamma radiation for cultural heritage materials has been widely applied around the world in the last decades. Adequate storage of photographic and cinematographic materials is a challenge for conservation experts from preservation institutions. Contamination by fungi is one of leading causes of problem in this kind of collections. In addition, another common physicochemical degradation affecting cellulose triacetate films causing deacetylation of polymer chain is called “vinegar syndrome”. In this work are presented results of effect of ionizing radiation on photographic and cinematographic films. Selected films were characterized by FTIR-ATR spectroscopy and FEGSEM-EDS microscopy. Samples were irradiated by gamma rays with absorbed dose between 2 kGy and 200 kGy. Irradiated samples were analyzed by UV-vis spectrophotometry, FEGSEM, thermogravimetric analysis (TG) and differential scanning calorimetry (DSC). Results showed that disinfection by gamma rays can be achieved safely applying radiation absorbed doses between 6 kGy and 10 kGy with no change or modification of main properties of the constitutive polymeric materials. Gamma rays due to the effect of crosslinking is presented as an alternative to treat films affected by “vinegar syndrome” applying absorbed dose of 50 kGy in order to increase shelf life of cultural heritage materials.

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Kinetics of Free Radicals Decay Reactions in Cellulosic Based Heritage Materials Disinfected by Gamma Radiation

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Keywords: free radicals decay; electron paramagnetic resonance; cultural heritage gamma irradiation.

Abstract

In this study, contemporary paper samples were irradiated using gamma radiation from Co-60 with different absorbed doses. The absorbed dose range was chosen taking into account the effective values to promote insect eradication, fungal disinfection and sterilization. The kinetics of decay of the cellulose free radicals induced by irradiation was analyzed using Electron Paramagnetic Resonance. Several spectra were obtained at room temperature for each applied absorbed dose immediately after irradiation as reference measurements. In order to understand the decay process of free radicals, additional spectra were obtained for different decay times up to almost 50 days after irradiation. De-noising treatment of the original obtained spectra signals were performed using wavelets. By integrating the electron paramagnetic resonance curves were calculated the area values and correlated to concentration, it is equivalent to spin concentration. Comparison of spectra was done by normalization of calculated area corresponding to cellulose spin concentration, considering the first measurement after irradiation as 100%. Further analyses and calculations were made to study the half-life and the kinetics models of the free radicals created. X-ray diffraction was carried out to identify crystalline phases and the effect of ionizing radiation on the crystalline structure of cellulose in paper. Scanning electron microscopy and Scanning Electron Microscopy Energy Dispersive Spectrometry were performed to analyze structure modifications by ionizing radiation, identifying cellulose fiber agglomeration zones and to quantify chemical elements. Likewise, samples were analyzed by infrared spectroscopy to determinate changes on the carbonyl groups. Results shown that for sterilization dose, 80% of the cellulose free radicals induced by ionizing radiation disappear in almost 40 days and for disinfection dose in 8 days. It can be concluded that if no significant modifications (side-effects) appear in the irradiated material after the radical decay time, the material will stay stable for the remaining lifetime. Proposed method using electron paramagnetic resonance results showed suitably to study the behavior of radicals on cellulosic based cultural heritage materials.

Gamma Irradiation: a Tool for Remedial Conservation - Consolidation of cultural heritage by radio-curable resin -

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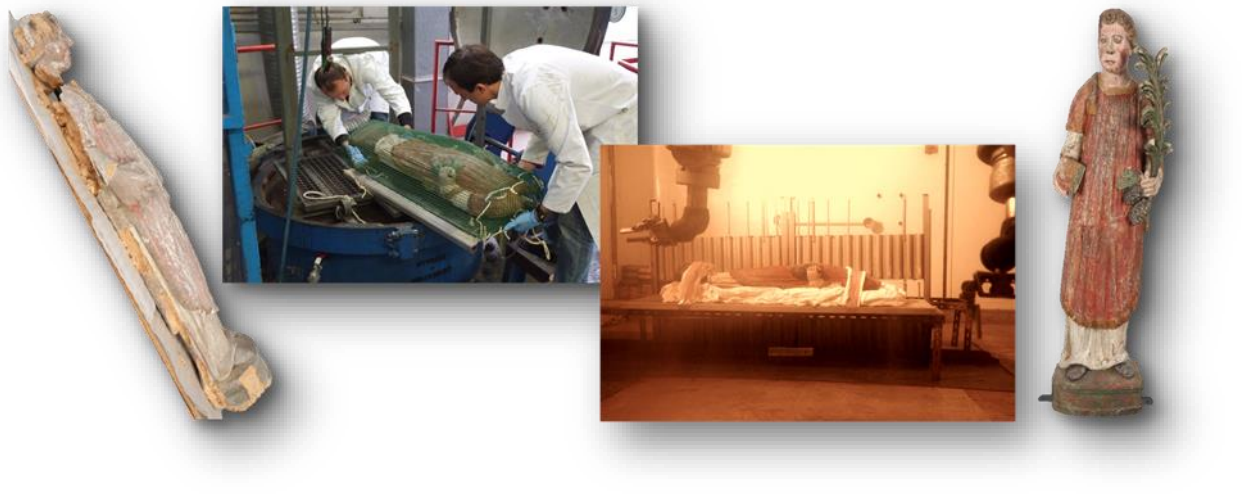
Keywords: gamma irradiation; consolidation of cultural heritage; artwork conservation.

Abstract

Consolidation using radio-curable resin is, with biocidal treatments, the other use of gamma irradiation for cultural heritage remedial conservation. Historically, it was the first application of gamma ray in the field of cultural heritage in Grenoble, with the consolidation in 1970 of a parquet floor by cabinetmakers Hache (18th c.) in the old Town Hall of Grenoble (wedding hall). From that time, it is known as “Nucléart” method, giving then its name to the consortium ARC-Nucléart (Atelier de recherche et de Conservation Nucléart).
In ARC-Nucléart, it is implemented for porous material-based artefacts, after classical vacuum/pressure impregnation of styrene/unsaturated-polyester resin. Microporosity have to be filled with the resin by this impregnation process. After letting dripping, the resin is evacuated from the larger holes, but remains in the microporosity thanks to capillarity. A key step is cleaning of resin that wets the surface, to avoid shine. There is time to do it carefully before launching the curing by the irradiation. With styrene/polyester, hardening is obtained by free-radical cross-linking copolymerisation after ionizations open carbon carbon double bonds, which allow to create new bridges with intermediate styrene between polyester molecules, resulting in a hard and stable 3D-net material.
The achieved consolidation is very efficient; it is referred as "densification" consolidation, as opposed to traditional consolidation techniques using solvents to "convey" a solid polymer into the material but needing then the evaporation of the part of the resin corresponding to the solvent to let only a film of solid in the porosity. Nucléart consolidation improves the physical-chemical properties, but also change the material. It is now a mixed of the original material with hard polymer. Wetting effect of the resin on some surface can also enhance some colours. Moreover, these changes are irreversible, so that the technique should be limited to cases when mechanical properties must really be substantially reinforced, for instance to preserve the structural function of the object or when it is so degraded that other conventional treatment can’t be undertaken (treatment of "last chance"). In other words, the use of this technique must be restricted and fully justified before being undertaken. Extremely worm-eaten wooden sculpture, polychrome or otherwise, give for instance some example of relevant cases for which it may have been impossible to save by other techniques.



Nucléart consolidation of a polychrome wooden sculpture of Saint Vincent (18th, Suzannecourt, France). From left to right: before treatment; polyester-styrene impregnation by vacuum/pressure; Gamma irradiation; after consolidation and restoration.
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This method was also adapted from the early seventies to the treatment of archaeological waterlogged wood. The challenge was to pass from a very degraded wood impregnated of 100% of water, to a wood impregnated of 100% of resin (that can't mix to water) without any drying phases that would have led to collapse of archaeological wood. It was made possible by double osmotic exchange via an intermediate solvent. However, due to complexity and the danger of this method, it is no more used. It is now preferred to treated waterlogged wood with conventional method, i.e. impregnation of polyethylene glycol (PEG) in water solution followed by freeze-drying, and then to process the nucleart method as for a dry wood, with vacuum / pressure impregnation. It is justified when PEG conventional method is not sufficient from mechanical point of view or from chemical stability point of view. This was the case for instance with the treatment of the prow of Roman Barge “Arles–Rhône 3” excavated from the Rhône river. Indeed this prow was surrounded by metal plates belt that was at risk of sulphur corrosion that would have been enhanced by the PEG content if only conventional method have been used. At the contrary, use of low content of PEG before treatment with hydrophobic styrene-polyester resin greatly mitigates this risk.

31 m long “Arles Rhône 3” Roman Barge: some part of the ship were treated by Nucleart method in order to avoid appearance of product of corrosion such as pyrite for the prow and to allow the reassembly in vertical position for the mast.
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