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Restoration of culturally significant wooden artifacts using gamma radiation curable polyester resins

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1. Introduction

The protection of cultural artifacts, especially those made of wood susceptible to damage from xylophagous organisms, fungi, and bacteria, is a constant concern for conservators and restorers. In general, various coatings based on resins and adhesives, ranging from natural products to synthetic polymers, have been employed for the preservation of these cultural artifacts. Gamma radiation, specifically derived from Cobalt-60, emerges as an innovative technique, offering advantages over traditional methods such as instantaneous effectiveness, absence of chemical residues, and the ability to penetrate deeply into treated objects, promoting pest and pathogen disinfection without damaging the material [1,2,3,4].

This study focused on gamma radiation-cured polymeric resins for the consolidation of three different wood species – cedar (*Cedrela spp*.), canafístula (*Peltophorum dubium*), and ivorywood (*Balfourodendron riedelianum*) – with the aim of applying them in the conservation and restoration of cultural heritage items. The research determined the optimal gamma irradiation conditions for resin curing without compromising the material's structure, characterized the resins post-irradiation, and impregnated the most suitable resin into wood samples.

2. Methodology

Unsaturated isophthalic polyester resin LP 8847®, with styrene (SM), supplied by the Reichhold group, and subjected to gamma irradiation to induce cross-linking. Tests were conducted on wood samples from canafístula, cedar, and ivorywood species, assessing the effectiveness of impregnation and consolidation.

The woods were cut, and their dimensions are presented in Table 1; then, they were placed in the reactor. A vacuum of 20 mmHg was applied to remove air from the wood pores. Next, the system was pressurized to 5 atm with nitrogen to establish an inert atmosphere, ensuring the absence of oxygen. The reactor was connected via a ¼-inch polyethylene hose to the tank containing the resin. The transfer of resin from the bottom to the top of the piece was carried out by positive pressure, thus filling the container. This impregnation process lasted 24 hours, ensuring complete impregnation in the pores of the wood. After impregnation, resin drainage was performed, followed by removing the woods from the reactor.

These woods were wrapped in cotton fabric and subjected to gamma irradiation in the Multipurpose Cobalt-60 Irradiator, located at the Radiation Technology Center (CETER). After 5 hours, the process was interrupted to remove the cotton fabric with excess resin, and the pieces were returned to complete the curing process.

The characterization of the samples involved the analytical techniques. Scanning Electron Microscopy (SEM) and Optical Microscopy (OM): Apparent Density Analysis: Measurement of the density of wood samples was performed using a precision balance, a container containing one liter of water, and a support for securing the wood sample.

Table 1 - Dimensions of samples from three wood species.

Canafístula Peltophorum dubium (Spreng.) Taub.	Pau-marfim Balfourodendron riedelianum (Engl.) Engl.	Cedro Cedrela spp., P. Browne
Length: 7.6 cm	Length: 4.9 cm	Length: 4.9 cm
Width: 1.9 cm	Width: 1.8 cm	Width: 4.9 cm
Thickness: 1.9 cm	Thickness: 1.8 cm	Thickness: 0.8 cm

3. Results and Discussion

Microscopic analyses, including optical microscopy (OM) figure 1, revealed the efficient penetration of resins into wood samples and the formation of a homogeneous polymeric matrix. These observations support the potential of radiocurable resins to fill pores and gaps in wood, contributing to structural consolidation and increased resistance to degradation.

Apparent Density of Wood Samples: The analysis of the apparent density of wood samples impregnated with resin showed an increase in density after treatment, indicative of the effectiveness of impregnation for structural reinforcement of the woods table 1 and 2. This result is crucial for the application of radiocurable resins in the conservation of wooden artifacts, offering a promising solution for the preservation of cultural heritage.

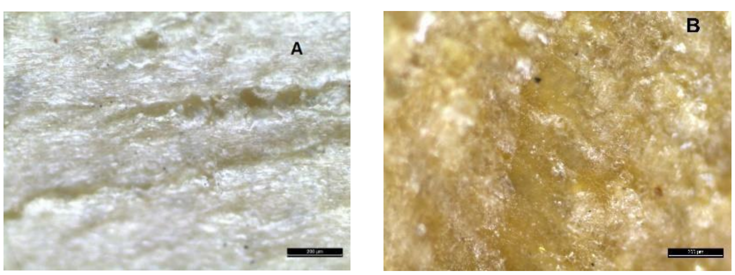

Figure 1 - Optical microscopy of Ivorywood sample - surface: a) before irradiation without resin; b) with resin and irradiated

Table 2 - Apparent density of non-irradiated wood samples, without resin impregnation

Sample	Specie	Dry weight (12%)	wet weight (12%)	Apparent density (Kg/m³)
1	Pau-marfim *Balfourodendron riedelianum* (Engl.) Engl.	21.2	23.81	0.8903

Table 3 - Apparent density of wood samples irradiated, with impregnated resin

Sample	Specie	Dry weight (12%)	wet weight (12%)	Apparent density (Kg/m³)
1	Pau-marfim *Balfourodendron riedelianum* (Engl.) Engl	17.71	19.43	0.9114

4. Conclusions

The results obtained in this study emphasize the effectiveness of radiocurable polyester resin LP 8847®, combined with SM, in the impregnation and consolidation of culturally valuable wooden artifacts. Future research could further explore the optimization of resin formulations and impregnation techniques. To improve the conservation and restoration of wooden sculpture that present has compromised structural degradation, which cannot be restored by other conventional techniques.

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