2024 International Nuclear Atlantic Conference – INAC 2024
Escola de Guerra Naval, Rio de Janeiro, RJ, May 6 - 10, 2024

ISBN: 978-65-594-1256-3

Paraloid Resins with Polymeric Monomers cured by Gamma Radiation for Consolidation of Porous Wood

Oliveira M. J. A., Araújo M.S. Otubo L, Mello Castanho S.R, Vasquez P. A. S

Nuclear and Energy Research Institute-IPEN-CNEN/SP. Av. Professor Lineu Prestes, 2242, Cidade Universitária CEP 05508-000, São Paulo-SP Brazil.

[1] *mariajhho@gmail.com*
[2] *pavsalva@usp.br*

1. Introduction

Preservation consists in an action that aims to guarantee the integrity and perpetuity of something, such as a cultural asset. One of the preservation instruments is restoration, an intervention that aims to definitively secure a product of human activity[1,2]. The cultural heritage presents an extensive diversity of wooden objects, which can be affected by insect attacks, causing severe damage to their structures. To recover this damage, compatible materials are needed to maintain their integrity[,3,4,5].
Therefore, we propose to study the obtaining of polymeric resins cured by gamma radiation. A series of formulations were developed with polymeric resins based on paraloid B72 and polymeric monomers cured by gamma radiation from a cobalt-60 source. These resins were characterized by physicochemical analyzes and the results presented were surprising in terms of reversibility. Gamma radiation replaced the catalyst, curing the resin 100% indicating new resin options for restoration and/or consolidation in porous wood.

2. Methodology

The reagents used in the formulations of this project were: paraloid B 72 resin, monomers: methyl methacrylate (MMA) and butyl methacrylate (MaBu), acetone, polyethylene glycol 6000, polyester, styrene. Several formulations were prepared with the commercial B72 paraloid resin with adding monomers, (MaBu), (MAM). The concentration was varied between the resin and monomers, or acetone resin, polyethylene glycol 6000 (PEG 6000), and polyethylene glycol 2000 (PEG 2000).

The formulations were placed in containers, homogenized and left to rest for 24 hours, for complete solubilization of the paraloid. After this period, they were homogenized again to eliminate bubbles and then the packaging was sealed. After this procedure, they were placed in the Cobalt-60 Multipurpose Irradiator of the Institute for Energy and Nuclear Research (IPEN) and exposed to gamma radiation, with a dose of 50 kGy and a dose rate of 1 kGy/h. After curing, physical chemical characterizations were carried out, including Gel Fraction and Thermogravimetry (TGA), Spectroscopy (FTIR), Raman Spectroscopy Scanning Electron Microscopy (SEM).

3. Results and Discussion

The proposed formulations with PEG 6000, PEG 2000, no crosslinking occurred and the paraloid formulations with acetone only formed a viscous gel. However, paraloid with polyester and paraloid with styrene cross-linked to form two phases, with different colors in the same sample.
The other formulations paraloid with MaBu, paraloid with MaBu and MMA, MaBu with MMA, and MaBu showed 100% crosslinking, after irradiated by gamma rays, without the need for a catalyst. The descriptions of the formulations are presented in table 1. The cross-linked samples were placed in a soxhlet extractor, with xylene solvent to obtain the insoluble gel fraction. It is observed in table 2 that after extraction the paraloid resin with MaBu is completely reversible.

At the same time that radiation promoted the crosslinking (curing) of these resins, we can verify that the curing is reversible, being extremely relevant for application in consolidation/restoration.

Table I: - Presents the results of the study realize out with the formulations proposed in this research for reversible resins.

Formulation	Negative result	Positive result
PEG 6000 20% + Aqueous solution 80%	X	
PEG 6000 78% + Aqueous solution 80%	X	
PEG 2000	X	
Paraloid B72 solubilized in 25% acetone (50% of the mixture) + PEG 2000 50%	X	
Paraloid B72 50% + acetone 50%	X	
Paraloid B72 75% + acetone 25%	X	
Paraloid 50% + styrene 50%	X	
Paraloid B72 35% + MMA 35% + polyester 30%	X	
Paraloid B72 30% + MaBu 30% + MMA 40%		X
Paraloid B72 30% + MaBu 70%		X
MMA 50% + MaBu 50%		X
MaBu 100%		X

Table II: Gel fraction in percentage of resins after extraction in xylene.

Samples	**Gel fraction %**
MaBu + paraloid	0.5
MaBu + paraloid + MMA	17.3
MMA + MaBu	7.2
MaBu	1.2

4. Conclusions

It is concluded that the formulations paraloid with MaBu, paraloid with MaBu and MMA, MaBu with MMA and MaBu presented 100% crosslinking, after gamma radiation, without the need for a catalyst. These resins were characterized by physicochemical analyzes and the results presented were surprising in terms of reversibility. Indicating new resin options for restoration and/or consolidation in porous wood.

Acknowledgements

The authors thank the project the 2020.06.IPEN.02, International Atomic Energy Agency (IAEA)

References

[1] Cortella, L. & Commission, A. E. Gamma Irradiation : a Tool for Remedial Conservation of Cultural Heritage - Biocide Treatment of Organic Materials and. (2022).

[2] Cortella, L., Albino, C., Tran, Q.-K. & Froment, K. 50 years of French experience in using gamma rays as a tool for cultural heritage remedial conservation. *Radiat. Phys. Chem.* **171**, 108726 (2020)

[3] IAEA. Uses of Ionizing Radiation for Tangible Cultural Heritage Conservation. *IAEA Radiat. Technol. Ser. No. 6* 92 pp (2017).

[4] Lungu, I. B., Miu, L., Cutrubinis, M. & Stanculescu, I. Physical Chemical Investigation of Gamma-Irradiated Parchment for Preservation of Cultural Heritage. *Polymers (Basel).* **15**, (2023).

[5] Ashfaq, A. *et al.* Polymerization reactions and modifications of polymers by ionizing radiation. *Polymers (Basel).* **12**, 1–67 (2020).