



Effects of ionizing radiation on artistic paints and pigments used in the restoration of works of art

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1. Introduction

Given the evident importance of society's Cultural Heritage, the notion of preserving the set of assets related to such a heritage is explained by the desire of keeping alive memory and the identity of a nation as well. Works of art are among the artifacts that constitute tangible cultural heritage.

In this sense, preserving and conserving, as well as anticipating damage that may arise means controlling, eliminating and reducing deterioration factors to which works of art of historical and aesthetic interest are exposed.

Beyond the conventional methods of controlling contaminants, ionizing radiation is an effective form of combating the deterioration of cultural heritage as it shows to be effective in eliminating biological infestations from the presence of insects to the contamination by fungi and bacteria. Ionizing radiation processing is given by the application of high doses of gamma radiation ^{60}Co . Radiated objects shall preserve intact their physical and chemical characteristics.

However, artifacts that suffer physical damage and pest attacks often need to be restored. The method of ionizing irradiation seeks to meet the parameters of conservation and restoration ethics, and might be a safe means to preserve the materials that make up the piece.

The objects of this research refer to 17 samples of canvas that have received layers of paints and pigments, both appropriate for the practice of restoring works of art. The sample received cumulative doses of gamma radiation so that its effects can be studied. Knowing the chemical constitution of the materials is essential for choosing and determining the ideal dose, avoiding secondary effects to the irradiated materials.

2. Methodology

Up to the date, the samples have been exposed to gamma radiation doses of 3, 5, 10, and 15 kGy from the Cobalt 60 Multipurpose Irradiator at the CTR-IPEN Radiation Technology Center, followed by polymethyl methacrylate (PMMA) dosimeters to ensure the desired values, with a dose rate between 5-6 kGy.h⁻¹. The objective is to determine the maximum limits to which the material can be exposed without undergoing significant changes on its physical-chemical properties.

The samples were prepared with 1x1cm without coating and for the characterization of the irradiated paints

and pigments, the following analytical techniques were initially used Electronic microscopy, Colorimetry and Spectroscopy (FTIR).

3. Results and Discussion

a) Electronic microscopy for morphological analysis of the surfaces of the samples, such as the examples in Figures 1, 2 and 3:

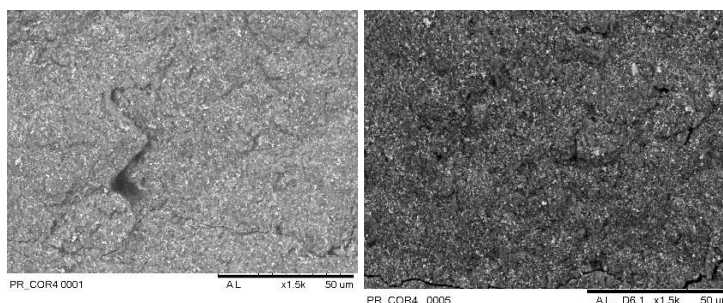


Figure 1: Sample PR_COR4; Left sample was not irradiated; Right sample was irradiated to 10kGy;

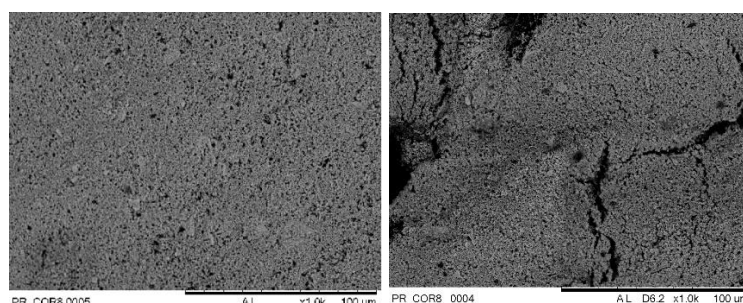


Figure 2: Sample PR_COR8; Left sample was not irradiated; Right sample was irradiated to 10kGy;

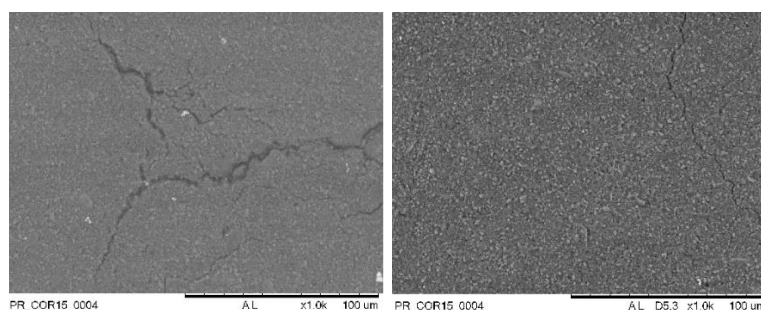


Figure 3: Sample PR_COR15; Left sample was not irradiated; Right sample was irradiated to 10kGy;

All 17 samples were analyzed but we highlight PR_COR4, PR_COR8 and PR_COR15 as example results. The electronic microscopy images showed unaltered surfaces. The cracks found may be the result of pressure and stress on the canvas.

b) Colorimetry to measure color changes before and after each session, as color is an important factor to evaluate the effects of radiation. Considering the reference values in Table 2 the results obtained with colorimetry showed that all irradiated samples remained below Hardeberg (1999) level 3, as illustrated in Table 1.

Table 1: Results obtained from samples PR_COR4, PR_COR8 and PR_COR15 irradiated with 3, 5, 10 and 15kGy.

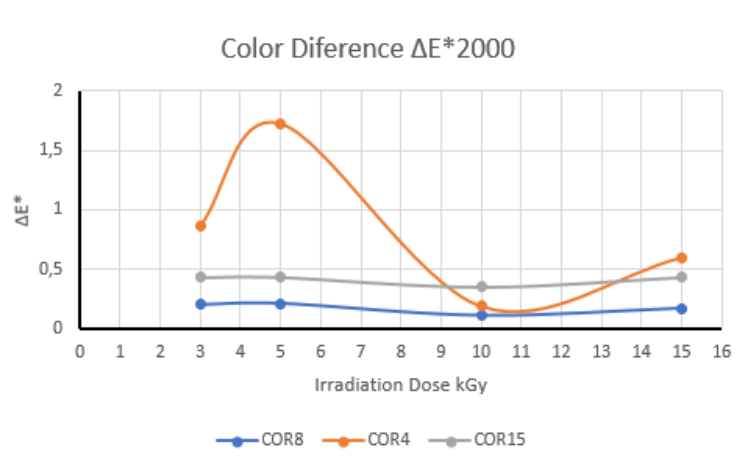


Table 2: Rules of thumb for the practical interpretation of ΔE^*_{ab} measuring the color difference by Hardeberg (1999).

ΔE^*_{ab}	Effect
< 3	Hardly perceptible
3 < 6	Perceptible, but acceptable
> 6	Not acceptable

c) Fourier Transform Infrared Spectroscopy (FTIR) before and after irradiation to evaluate changes or formation of organic chemical groups, such as the examples in Figure 4:

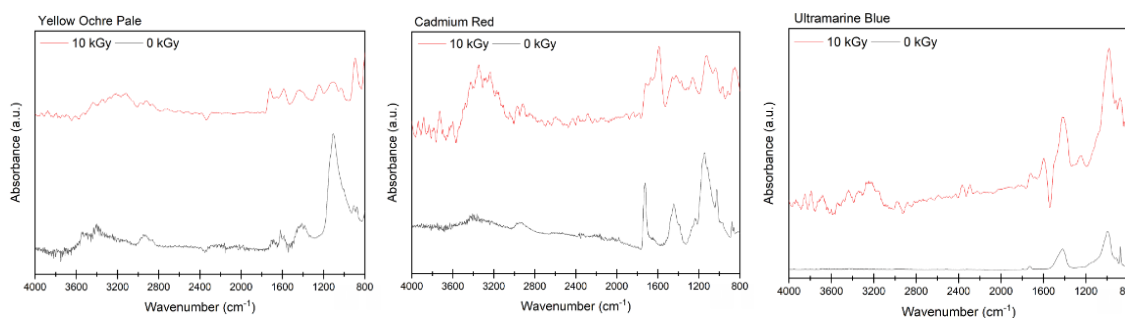


Figure 4: From left to right, FTIR spectra of samples PR_COR4, PR_COR8 and PR_COR15 with 0kGy and 10kGy;

The PR_COR4 sample irradiated with 10kGy showed a characteristic peak of H₂O and C-H, in the approximate region of 3000, which could mean ambient humidity. The peak in the region of 1,100 presents lower intensity, compared to 0kGy. The PR_COR8 sample irradiated with 10kGy showed greater intensity in the region of 3000, assuming that the sample had absorbed unity from the environment. In the other regions there were no significant changes. The PR_COR15 sample irradiated with 10kGy showed greater intensity for the characteristic peaks in the 3000, H₂O and C-H region and in the 1000, C-N and C-H region, when compared to 0kGy.

4. Conclusions

According to the results obtained so far, it is possible to conclude that the ionizing radiation processing with gamma rays from Cobalt 60 Multipurpose Irradiator did not change significantly the color of the analyzed samples – given that they represent a small sample taking into account the variety of colors, paints brands and pigments for painting restoration offered on the market. Continuity of research is deemed essential for conservation-restoration professionals to be confident when using available stable materials and also to contribute to the preservation of cultural heritage.

Acknowledgements

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References

- [1] Rizzo, M.M., *et al.* Effects of gamma rays on a restored painting from the XVIIth century. *Rad.Phys. Chem.* 63, 252–259 (2002).
- [2] Negut, D.C., *et al.* Effects of gamma irradiation on the colour of pigments. *Proc. SPIE*, Vol. 6618, O3A: Optics for Arts, Architecture and Archaeology, R1-10 (2007).
- [3] Negut, D.C., *et al.* Defects induced by gamma irradiation in historical pigments/ *Journal of Cultural Heritage* 13 (2012) 397–403 (2012).
- [4] Mihaela Maria Manea, *et al.* Irradiation effects on canvas oil painting: spectroscopic observations, *Radiation Physics and Chemistry*, vol.81, ed 10, pp. 1595-1599 (2012).
- [5] Hardeberg, J. Acquisition et reproduction d'images couleur : approches colorimétrique et multispectrale. *Interface homme-machine [cs.HC]*. Télécom ParisTech. Français (1999).