Objects from Indigenous and World Cultures

ICOM-CC Beijing 17-21 MAY 2021
TRANSCENDING BOUNDARIES: INTEGRATED APPROACHES TO CONSERVATION

ICOM-CC ICOM international council of museums – committee for conservation

Application of Gamma irradiation to conservation: Effects of ionizing radiation on the color of featherwork

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Introduction

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. 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 [1]. 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).

Materials and experimental

Samples of macaw feathers from a head ornament of the Kayapó indigenous group Xikrin who lives in villages in Pará, Brazil were used in this work. Two feathers (Fig. 1) were selected and removed from the feather adornment. The numbering of the samples indicates the order in which the feather was attached to the ornament.

Sample	Side	Sampling points and predominant colors	Notes
Feather 5	Front	C: Blue D: Grayish E: Blue	D: Loss area
	Back	A: Red B: Red	B: Loss area
Feather 31	Front	C: Blue D: Red E: Red	E: Loss area
	Back	A: Red B: Red	B: Loss area

***Figure 1**: Samples selection and measuring points.*

Irradiation by Gamma Rays from Cobalt-60 Sources

Feather samples were irradiated with gamma rays from cobalt-60 at the Multipurpose Gamma Irradiation Facility of the Nuclear and Energy Research Institute – IPEN-CNEN/SP (Fig.2). Samples were irradiated by gamma rays with absorbed doses of 0.5, 1.0, 2.5, 6, 10, 15, 25, 50, 75, 100 and 200 kGy, and the dose rate was 5-6 kGy/h.

***Figure 2:** Multipurpose Gamma Irradiation Facility.*

Colorimetric Measurements

The colorimeter PCE-CSM8 was used to measurement points were chosen among the two samples according to the colors of the feathers. Each sample was read twice using colorimetry with CIELAB 1976 color space scale (before and 48 hours after each radiation absorbed dose). Color fading was estimated considering the criterion proposed by Hardeberg [2] about the relationship between ΔE and the perception of color change (Table 1).

ΔE*	Effect
< 3	Hardly perceptible
3 < 6	Perceptible, but acceptable
> 6	Not acceptable

***Table 1:** Hardeberg Criteria for the interpretation of ΔE*.*

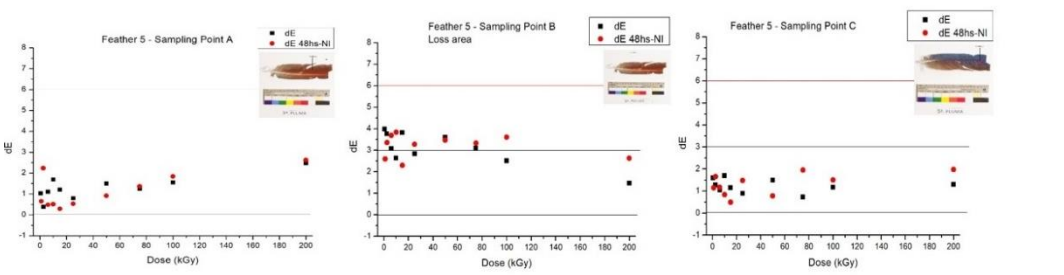
Field-emission Gun Scanning Electron Microscopy

The surface of the samples were analyzed by scanning electron microscopy (FEGSEM), using a Jeol JSM-6701F electron microscope with a field emission gun operating at 2kV and 3kV with a coupled Thermo EDS detector.

References

1. AIEA, "Uses of ionizing radiation for tangible cultural heritage conservation". IAEA Radiation Technology. Series Nº 6, Vienna (2017).
2. J.Y. Hardeberg, "Acquisition et reproduction d'images couleur: approches colorimétrique et multispectrale". Interface homme-machine [cs.HC], Ecole Nationale Supérieure des Télécommunications - Télécom. ParisTech, France (1999)

Results and Discussion



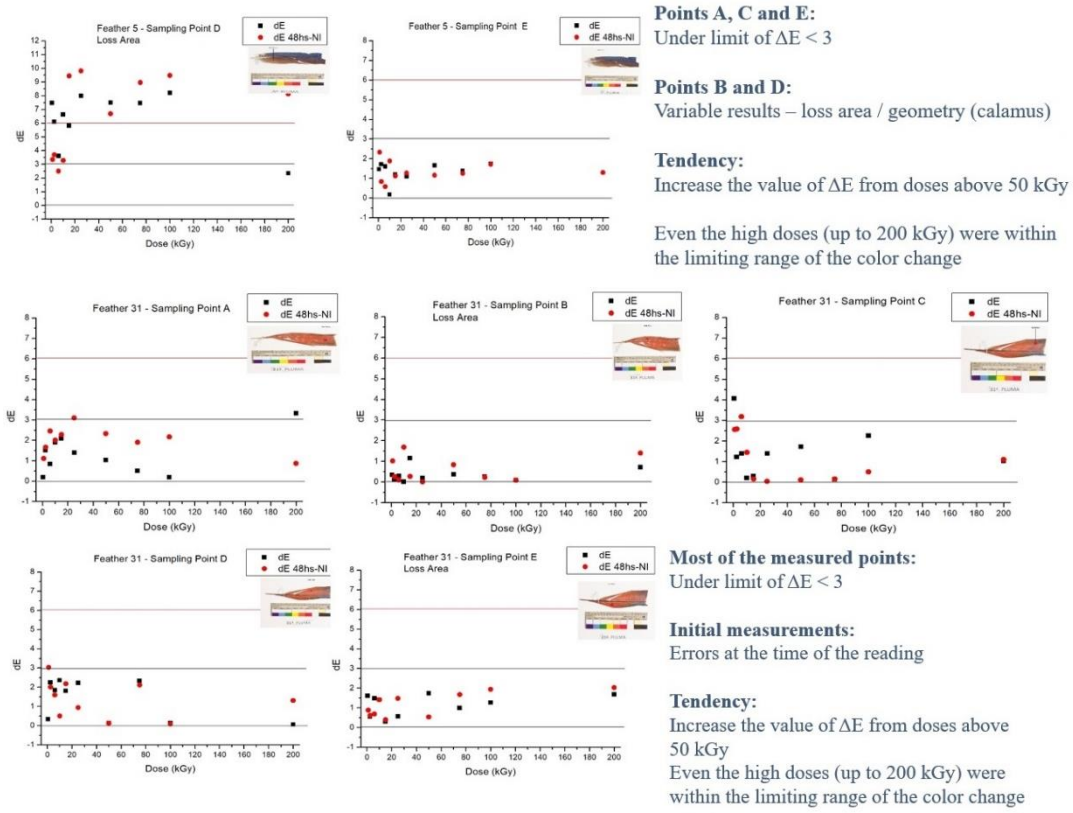


***Figure 3 and 4**: Color changes – Feather 5 and 31.*

As shown in Fig. 4 and 5, the points A, C and E measured in feather 5 and most of the measured points of feather 31 are within the limit of ΔE < 3, thus implying a hardly perceptible color change. Some measurements show ΔE > 3 and we suggested that these variations may have been caused by since they were areas of losses that could have their readings affected. In addition, some points were close to the central stem of the feather (*calamus*), which may have made it difficult to read or may be only errors caused by a different positioning at the sampling point. The figures 6 and 7 show different morphological structures and small dust particles in the two samples at different resolutions. No effect of the irradiation on the structure of the samples can be noted on the SEM images of non-irradiated and gamma irradiated samples.

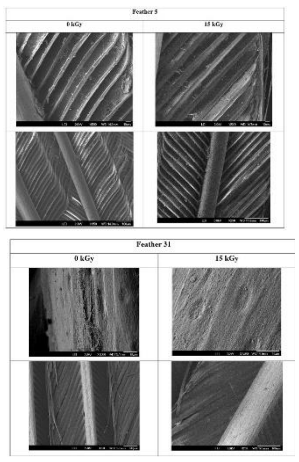


***Figure 5 and 6**: FEGSEM images – Feather 5 and Feather 31.*

Conclusions

The colorimetric analysis showed that there was no significant change in the irradiation range applied in this experiment (ΔE = < 3). Although we have applied high doses like 200 kGy, the feathers did not undergo perceptible chromatic alterations. Colorimetric readings of feathers can be complex: the material is translucent and has different colors and geometry. The areas of losses can offer misleading readings. We recommend avoiding these areas as points of analysis.

The FEGSEM images also proves that up to 15 kGy radiation absorbed dose the samples did not present differences in their morphological topography. The results indicate that feather artifacts can be subjected to gamma radiation without their colors being affected. Higher doses are not necessary for usual treatments against biological infestations. The recommended treatment dose in the case of an insect attack is 0.5 kGy but can be up to 2 kGy. This dose is also effective for eradication of insect eggs [1].

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