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Analysis of the Effects of Gamma Radiation on Commercial Photographic Lenses.

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1. Introduction

The concern with optical materials and their deterioration processes began to gain scientific relevance when, in 1939, Australian soldiers on mission in New Guinea started reporting a widespread proliferation of fungi on their equipment and were unable to halt the contamination or repair the affected materials. [1] The growth of fungi on cameras and photographic lenses directly affects image quality — not only in terms of the sharpness of the final image, but also regarding the structural integrity of the lens itself. In order to feed, fungi secrete substances capable of corroding both the lens coating and the glass. Prolonged exposure of the lens to fungal growth can cause loss of focus, decrease in optical transmittance, resulting in underexposed images, and ultimately complete obstruction of the optical path.

Faced with these damages, researchers began seeking effective solutions for eliminating fungi from optical materials. Among the agents studied are fungicides, X-rays, and alpha particles. [2]

Gamma radiation has been extensively investigated as an effective approach for fungal inactivation, with studies demonstrating that doses ranging from 1 kGy to 10 kGy are effective in eliminating fungi in their vegetative form, as well as in reducing spore viability. [3]

In light of these findings, the present study aimed to evaluate the darkening and recovery rate of commercial lens samples from Nikon and Canon subjected to gamma radiation (^{60}Co) at a dose of 5 kGy. This dosage, equivalent to half the upper limit typically employed in fungal control, was selected to test the applicability of the method as a preliminary step in the cleaning process of photographic optical assemblies. The proposal is to promote the biological inactivation of microorganisms and reduce the risk of spore dispersal during handling, thereby minimizing the likelihood of environmental and lens contamination.

2. Methodology

From each optical assembly analyzed, two lenses were selected. Samples of approximately

42 mm × 13 mm were cut from each lens to enable pre- and post-irradiation absorbance measurements using a UV-Vis spectrophotometer (Genesys 180, Thermo Fisher Scientific).

Following the initial measurement, the samples were divided into two groups: the first was irradiated at ambient temperature, and the second was placed in a container with ice during irradiation.

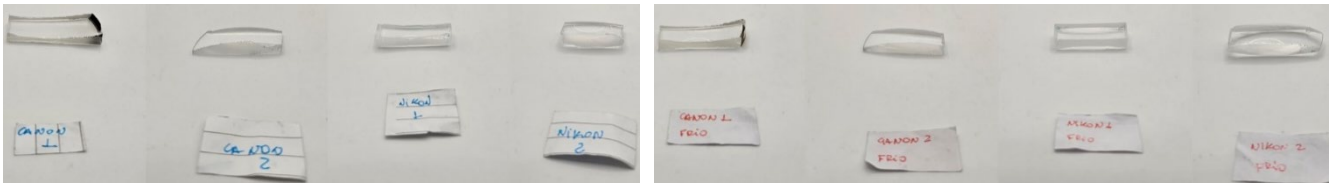

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Figure 1: Pre-irradiation samples: (A) ambient temperature; (B) ice container.

All samples were irradiated in a ^{60}Co Gamma Chamber at a dose rate of 7,743 kGy/h for 38 minutes and 44 seconds, yielding a total absorbed dose of 5 kGy. Throughout the irradiation period, temperature variations inside the irradiator were recorded. The ambient-temperature group exhibited a temperature increase of 6.8 °C, rising from 20.7 °C to 27.5 °C, whereas the ice-cooled group showed a more moderate increase of 3.9 °C, from 27.1 °C to 31.0 °C.



Figure 2: Gamma Chamber 5000

Subsequently, absorbance measurements were performed periodically over a six-month period to monitor the radiation-induced optical degradation and the spontaneous thermal fading process.

3. Results and Discussion

After irradiation, all eight samples exhibited a significant change in coloration, acquiring a characteristic yellowish tint associated with this procedure, which impacted the absorbance of all fragments, predominantly in the blue region of the spectrum (< 450 nm).

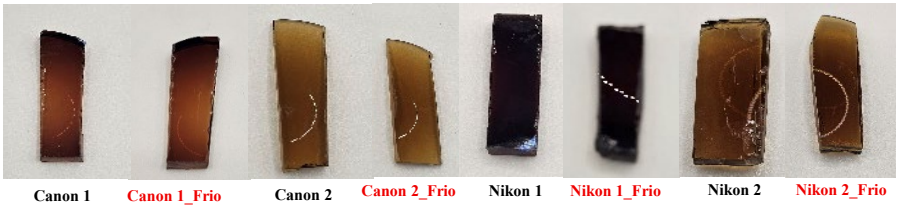

Figure 3: Initial coloration of the samples after irradiation.

Analysis of the data revealed that the different irradiation temperatures did not produce significant variations in the samples' response to radiation. In contrast, when comparing the two lens brands evaluated, the differences in effect are more pronounced. Nikon lenses exhibited greater initial darkening (mean absorbance of ~0.23–0.35 Abs) compared to Canon lenses (~0.13–0.21 Abs). [4]

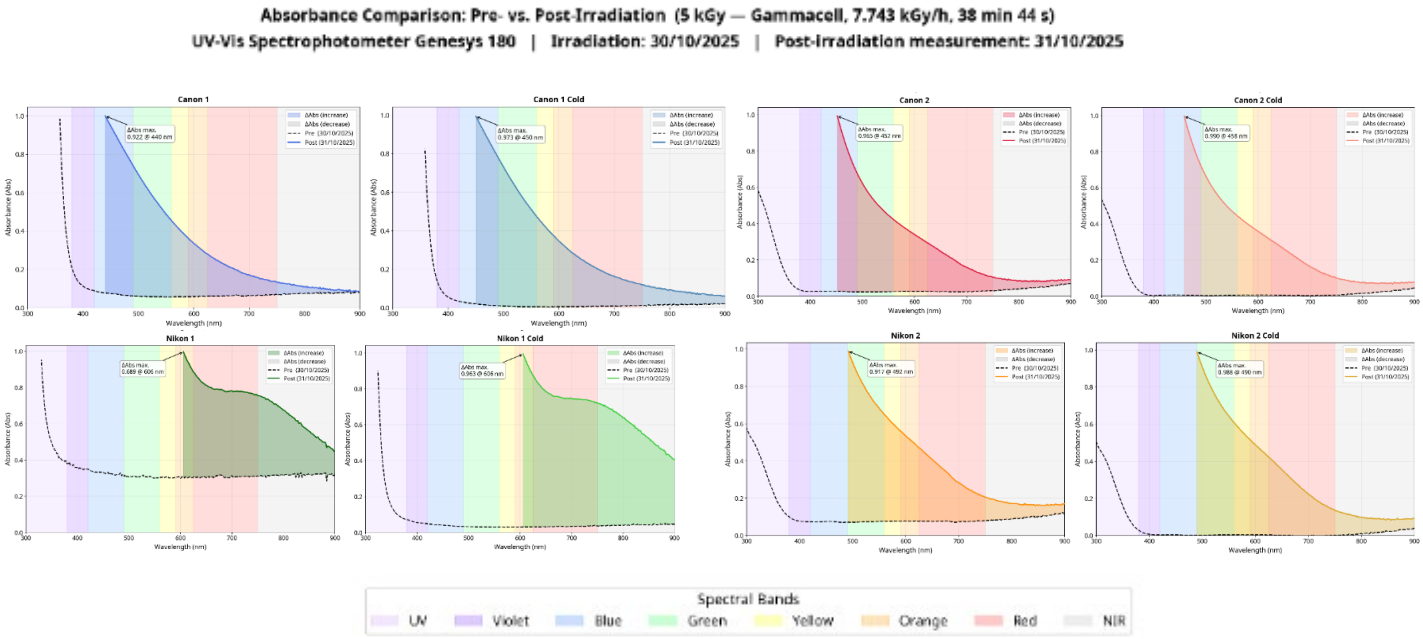

Figure 4: Comparative absorbance spectra before and after irradiation.

Over the approximately six-month monitoring period, thermal fading at ambient temperature, although slow, proved to be continuous. Nikon lenses displayed faster discoloration rates compared to Canon lenses, as well as a selective spectral recovery, with the green and red bands regenerating more rapidly than the blue and violet bands. [5]

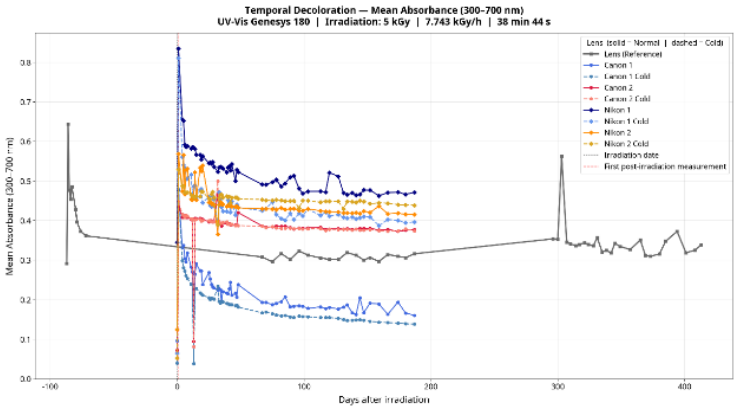

Figure 5: Average Absorbance vs. Time

The results obtained indicate that gamma irradiation may present potential for the decontamination of optical assemblies when combined with complementary methods to accelerate transparency recovery — such as thermal bleaching [5], exposure to visible light, and other strategies that would reduce spontaneous fading time and restore lens transmittance values within shorter timeframes.

4. Conclusion

The results obtained demonstrate that all lenses underwent progressive optical darkening, evidenced by a significant increase in UV-Vis absorbance immediately after irradiation, followed by a gradual recovery over the six-month monitoring period. However, spontaneous thermal fading proved to be slow and continuous, and may not, in some cases, be sufficient to fully restore the initial absorbance values.

The samples irradiated at ambient temperature and under ice-cooled conditions showed no significant differences in optical response, indicating that mild cooling — achieved by placing the samples in an ice container — was insufficient to inhibit the formation of radiation-induced color centers during irradiation.

The efficacy of the 5 kGy dose employed is supported by the literature [6] established that a dose of 1.26 kGy is sufficient to achieve a six-log reduction of Aspergillus niger in cotton substrate, while Santos et al. [7] reported that doses of 2.0 kGy effectively reduce fungal load in peanut seeds. It can therefore be concluded that the dose of 5 kGy is effective for the biological decontamination of photographic lenses, representing a viable preliminary step in the cleaning of optical assemblies.

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