



ELSEVIER

Contents lists available at ScienceDirect

Radiation Physics and Chemistry

journal homepage: www.elsevier.com/locate/radphyschem

Effect of gamma irradiation on Korean traditional multicolored paintwork

Minchul Yoon^{a,*}, Dae-Woon Kim^d, Jong-il Choi^c, Yong-Jae Chung^b, Dai-Il Kang^b, Gwang Hoon Kim^d, Kwang-Tae Son^a, Hae-Jun Park^e, Ju-Woon Lee^e^a Food Safety Research Division, National Fisheries Research & Development Institute, Busan 619-705, Korea^b Department of Conservation Science, Korean National University of Cultural Heritage, Buyeo 323-812, Korea^c Department of Biotechnology and Bioengineering, Chonnam National University, Gwangju 500-757, Korea^d Department of Biology, Kongju National University, Gongju 314-701, Korea^e Advanced Radiation Technology Institute, Korea Atomic Energy Research Institute, Jeongseup 580-185, Korea

HIGHLIGHTS

- Effects of gamma irradiation on the Dancheong were evaluated.
- We confirmed that optical and structural properties of Dancheong were maintained.
- Irradiation can contribute the decontamination for wooden cultural heritages.
- It also can be used for preservation of painted-wooden cultural heritages.

ARTICLE INFO

Article history:

Received 10 July 2014

Received in revised form

1 May 2015

Accepted 13 June 2015

Available online 17 June 2015

Keywords:

Gamma irradiation

Korean traditional multicolored paintwork

CIE color values

X-ray diffraction analysis

Fungicidal and insecticidal effect

Preservation

ABSTRACT

Gamma irradiation can destroy fungi and insects involved in the bio-deterioration of organic cultural heritages. However, this irradiation procedure can alter optical and structural properties of historical pigments used in wooden cultural heritage paintings. The crystal structure and color centers of these paintings must be maintained after application of the irradiation procedure. In this study, we investigated the effects of gamma irradiation on Korean traditional multicolored paintwork (Dancheong) for the preservation of wooden cultural heritages. The main pigments in Korean traditional wooden cultural heritages, *Sukganju* (Hematite; Fe₂O₃), *Jangdan* (Minium; Pb₃O₄), *Whangyun* (Crocoite; PbCrO₄), and *Jidang* (Rutile; TiO₂), were irradiated by gamma radiation at doses of 1, 5, and 20 kGy. After irradiation, changes in Commission Internationale d'Eclairage (CIE) color values (L^* , a^* , b^*) were measured using the color difference meter, and their structural changes were analyzed using X-ray diffraction (XRD) analysis. The slightly change in less than 1 dE^* unit by gamma irradiation was observed, and structural changes in the Dancheong were stable after exposure to 20 kGy gamma irradiation. In addition, gamma irradiation could be applied to painted wooden cultural properties from the Korean Temple. Based on the color values, gamma irradiation of 20 kGy did not affect the Dancheong and stability was maintained for five months. In addition, the fungicidal and insecticidal effect by less than 5 kGy gamma irradiation was conformed. Therefore, the optical and structural properties of Dancheong were maintained after gamma irradiation, which suggested that gamma irradiation can be used for the preservation of wooden cultural heritages painted with Dancheong.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Cultural heritages consisting of natural materials such as wood (Pointing et al., 1998), paper (Choi et al., 2012), silk (Annamaria et al., 1998), and leather (Sterflinger, 2010) are influenced by

natural damage caused by microbial biodegradation, especially by fungi. Thus, it is important to examine the effects of biodegradation on these organic materials and develop techniques to control this biodegradation. Numerous techniques have been applied for decontamination and conservation of organic cultural heritages. In particular, decontamination of wooden objects by gamma irradiation has been applied in France since 1970 and in the Czech Republic since 1982 (Ramière, 2002).

* Corresponding author. Fax: +82 51 720 2619.

E-mail address: yoonec@korea.kr (M. Yoon).

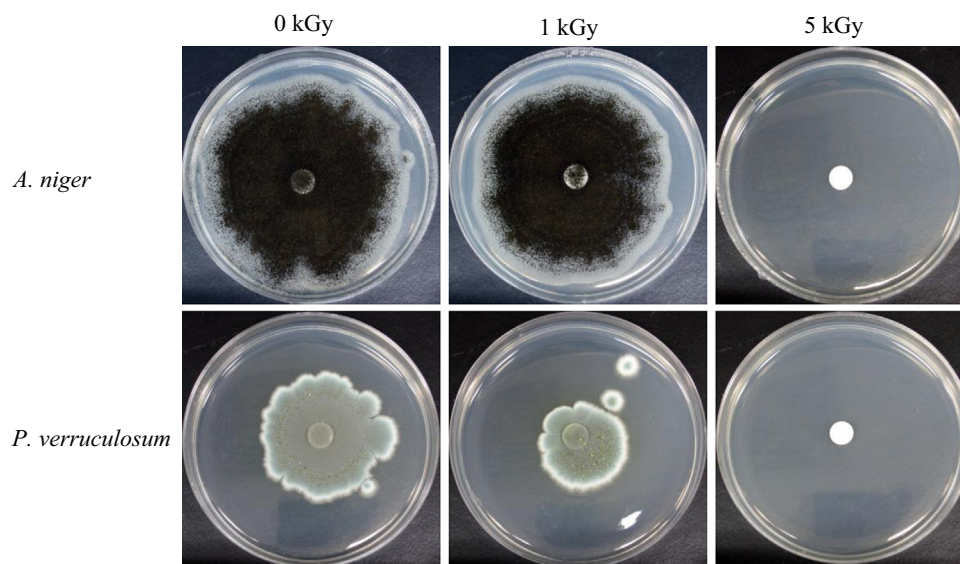


Fig. 1. Inactivation of wood decaying fungi after gamma irradiation. At dose of 5 kGy, wood decaying fungi was not survived.

Gamma radiation has high penetrating power and causes direct and indirect damage to cell DNA, thereby inducing cell death. As a decontamination technique, it is also used to control decaying microorganisms on organic materials such as paper and wood, which are common components of cultural heritage objects (Ne-gut et al., 2012). It has been suggested that this technique is non-toxic and that radioactive residues do not remain on the object. In addition, a large number of objects can be treated quickly at a low cost. Recently, gamma irradiation was applied for the disinfection of contaminated papers (Tomazello and Wiendl, 1995; Gonzalez et al., 2002), waterlogged archeological wood (Pointing et al., 1998), pure cellulose paper (Adamo et al., 1998), and biodeteriorated books (Da Silva et al., 2006; Magaudda, 2004). In Korea, gamma irradiation was used as a decontamination technique for Korean traditional paper (Choi et al., 2012) and wooden cultural properties (Yoon et al., 2011). Although the stability of target objects and the effectiveness of microbial decontamination by irradiation were demonstrated, the side effects on other materials, such as pigments and coating agents, should be considered.

Korean traditional multicolored paintwork (Dancheong) refers to multicolored decorative paintings on the surface of traditional Korean wooden buildings. Dancheong is used to improve the esthetic appeal of wooden buildings. Moreover, it is used to hide scratches on surfaces and protect surfaces from natural damage and biodegradation (Jang et al. 2010). In Korea, Dancheong is commonly applied to wooden buildings and ancient tomb murals, handicrafts, statues, and accessories (Jang et al., 2010). If the wooden cultural properties are irradiated to control biodegradation, the pigments can also be affected. At the same time, radiation can have unwanted effects on the irradiated object. Therefore, further studies are required to develop irradiation methods to disinfect cultural properties.

In this study, inactivation effects of fungi and insects by gamma irradiation and changes in optical and structural properties of the Dancheong after gamma irradiation were evaluated. To assess optical changes of the Dancheong after gamma irradiation, color changes were analyzed using the color difference meter. The structural properties were also analyzed using X-ray diffraction (XRD). Overall, we demonstrated that gamma radiation could be used to treat painted wooden cultural properties in the Korean Temple.

2. Materials and methods

2.1. Experimental materials

The main pigments of Korean traditional wooden cultural heritages, *Sukganju* (Hematite; Fe_2O_3), *Jangdan* (Minium; Pb_3O_4), *Whangyun* (Crocoite; PbCrO_4), and *Jidang* (Rutile; TiO_2), were kindly provided by the Korean National University of Cultural Heritage. Among them, in Korea, the Hematite has been commonly used as painting pigments in column of traditional wooden building. Moreover, the Minium and Crocoite have been also used in traditional cultural heritages. However, it has been known that these pigments were easily depredated by environmental condition. In case of the Rutile, since 1910s, it began to be used for painting pigment as white pigment. Although the Rutile is not modern pigment, it is representative pigment in Korean traditional cultural heritages. Therefore, in consideration of its representative nature and environmental vulnerability, four pigments were used for the study. Furthermore, the painted wooden cultural property, which was replaced after maintenance work, was also provided by the NaeJang Temple in Jeongeup, North Jeolla Province, Korea.

The wood decaying fungi, *Aspergillus niger*, and *Phenicillium verruculosum*, and the adult insects, *Reticulitermes speratus*, *Lasioderma serricorne*, and *Sitophilus oryzae*, used in the study were kindly provided by the Korean National University of Cultural Heritage. All fungi were incubated on potato dextrose agar (PDA, Becton Dickinson) medium to examine the anti-fungal activity of gamma irradiation.

2.2. Gamma irradiation

A cobalt-60 gamma irradiator at the Korea Atomic Energy Research Institute, Jeongeup, Korea (150 TBq capacity; ACEL, MDS Nordion, Canada) was used for irradiation at doses of 0.5, 1, 2, 5, and 20 kGy. All absorbed doses were calibrated using alanine dosimeters with a diameter of 5 mm (Bruker Instruments, Rheinstetten, Germany), and a Bruker EMS104 EPR analyzer (Bruker Instruments, Rheinstetten, Germany) was used to determine the free-radical signals.

Download English Version:

<https://daneshyari.com/en/article/8252793>

Download Persian Version:

<https://daneshyari.com/article/8252793>

[Daneshyari.com](https://daneshyari.com)