γ-ray Irradiation Effects on the Polypropylene Yarns

N.O. Chang[1),2)], H.J. Won[1),*], S.Y. Park[1)], S.B. Kim[1)], B.K. Seo[1)] and Y.S. Kim[2)]

[1)] Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea

[2)] Hanyang University, 222, Wangsimri-ro, Seongdong-gu, Seoul, Republic of Korea

[*] nhjwon@kaeri.re.kr

1. Introduction

During the decommissioning, a chemical decontamination process is used for removing the radionuclides by dissolution of oxide layer on the primary system of nuclear power plant. It consists of oxidizing and reducing processes. As a reducing decontamination agent, N_2H_4-Cu(I)-H_2SO_4 solution developed by KAERI can be applied. Radioactive liquid wastes produced after the decontamination process should be treated because it contains the radioactive materials. The filter press is used for the removal of radioactive materials in the radioactive liquid wastes as a solid form [1]. Polypropylene (PP) fabric is used as the filter medium. The filter press is operated up to a 1 MPa. PP filter, however, can be degraded during the treatment process due to the γ-ray exposure by the radioactive waste. In this study, the γ-ray irradiation effects on the mechanical properties of PP yarns are analyzed. The variations of surface morphology of PP yarns after inducing γ-ray are also analyzed.

2. Methods and Results

2.1 Sample preparation and γ-ray irradiation

PP yarns having a thickness of 450 deniers were cut into 200 mm. The samples were irradiated with 0, 20 and 40 kGy of γ-rays in the air condition by using a Low-dose γ-ray Irradiator (Co-60 source) in the Jeonup City (Korea Atomic Energy Research Institute).

2.2 Mechanical properties of the PP yarns

To evaluate the mechanical properties of the PP yarns, tensile tests by the universal tester (INSTRON 4482, Instron Corporation) were carried out. The results of the tensile test are presented in Fig. 1.

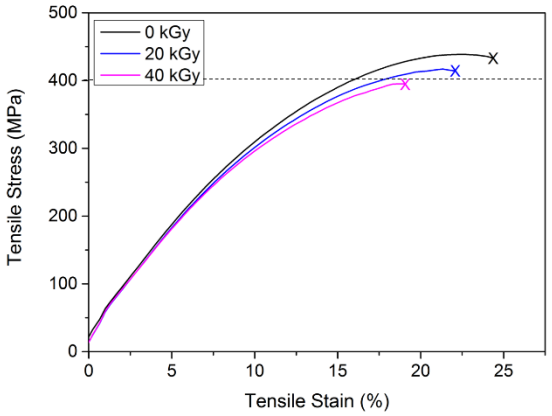

Fig. 1. Tensile Stress-Tensile Strain curves of PP yarns before and after γ-rays irradiation.

As shown in Fig. 1, the tensile stress at break (× marks) decreases with the increase of the absorbed dose. This phenomenon occurs because of the chain scission of the C-C bonding occurs in the PP yarns. During and after the γ-ray irradiation, oxygen atoms in the air are converted to the radicals and decompose to carbonyl and hydroxyl compounds. These compounds cause the chain scission of C-C bonding in the PP yarns, which is the reason of the degradation [2].

For all the PP yarn samples, the tensile stress at break is about 400 MPa. When the PP is used as a filter, the filters receive a pressure. Therefore, the mechanical degradation of PP yarns due to the γ-ray irradiation can be ignored within absorbed doses in this study.

2.3 Surface properties of the PP yarns

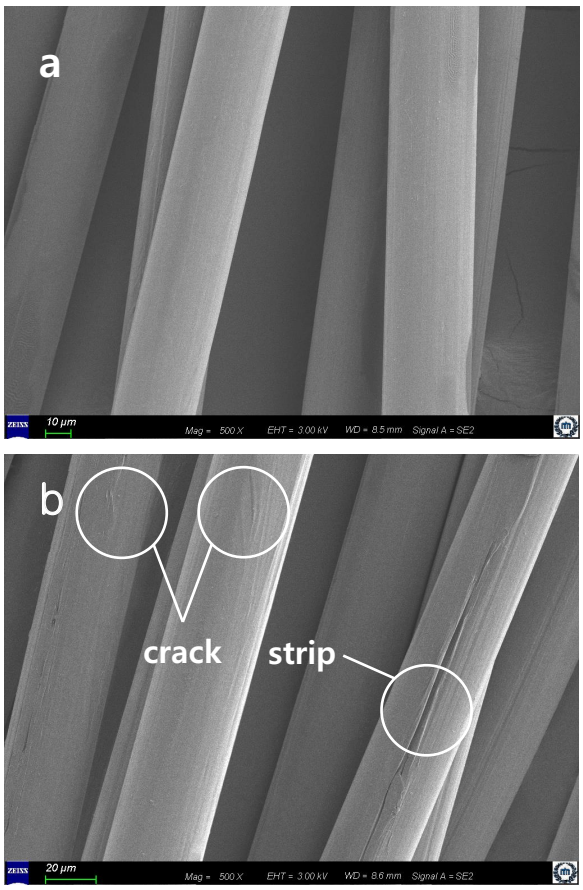

Fig. 2. Surface change of the PP yarns, (a) 0 kGy and (b) 40 kGy of absorbed dose by γ-rays irradiation.

The surface change of the PP yarns is observed by FE-SEM(JSM-7000F, ZEISS Co. Ltd) and shown in the Fig. 2. The PP filaments before irradiation have sound surface as shown in the Fig. 2a. However, after PP yarns received the 40 kGy of absorbed dose, cracks and long strips occur along the outer PP filaments. It is difficult to observe the change of the morphology on the inner PP filament. Therefore, it can be predicted that the degradation of PP yarns occur from the outside to the inside.

3. Conclusions

During the treatment of radioactive liquid wastes, PP filters are degraded by γ-ray irradiation. This phenomenon can be explained by C-C bond scission of PP yarns. In the absorbed dose range of this study, PP yarns have the resistances against pressures up to 400 MPa. The maximum operating pressure of the filter press is 1 MPa. Comparing the maximum tensile strength and the operating pressure, it can be concluded that the negative effect by γ-ray irradiation can be neglected during the filtration. PP yarns, however, contact with water during the real decontamination process. Thus, it is necessary to study the effects of γ-ray irradiation on PP yarns in a water condition.

ACKNOWLEDGMENT

This work has been carried out under the Nuclear R&D Program (NRF-2017M2A8A5015144) funded by Ministry of Science and ICT.

REFERENCES

[1] International Atomic Energy Agency, Application of Membrane Technologies for Liquid Radioactive Waste Processing, Technical Reports Series, No. 431 (2013).

[2] Miroslav Mrlík and Mariam Al Ali Al Maadeed, Tailoring of the thermal, mechanical and dielectric properties of the polypropylene foams using gamma-irradiation, Polymer Degradation and Stability, No. 133, p. 234-242 (2016).