A Study of Mechanical Properties of Polymer Composite Containing Tungsten Nano/Micro-Powder for Radiation Applications

Duckbong Seo, Jaewoo Kim, Jun-hyung Lee, Jungkuk Lee
Nuclear Materials Research Division, Advanced Radiation Technology Institute
Korea Atomic Energy Research Institute
1045 Daeduckdaero, Yuseong-Gu, Daejeon 303-305 Republic of KoreaAuthor
E-mail : seodb71@kaeri.re.kr

1. Introduction

Polymer composites are closely related and widely used in human life. Polymer composites have not only perfect physical and chemical properties for industrial goods but also relatively inexpensive price. In addition, manufacturing processes are relatively easy comparing with metallic ones. Polymer composites are being utilized in a lot of fields such as plastic products, packaging things, and radiation shield. In particular, interesting of polymeric materials to prevent radiation is gradually increased for last few years [1, 2]. In addition, nano or micro-scale powder, such as tungsten (W) and lead (Pb), can be dispersed in polymer composites to enhance ability of radiation shield. Therefore, the researches for polymer composites containing nano or micro-scale high density elements are gradually tried recent years [3]. In addition, the environmental issues gradually demand the less use Pb for radiation shield area. However, experimental results of mechanical properties, such as tensile strength and elongation, for these composites are still lack and much required to apply for industrial approaches. It is also important to know mechanical properties of these composites to maintain stability after forming or manufacturing, especially, for radiation shield purpose. In the paper, we introduce the experimental results of mechanical properties about such polymer composites which are completed with mixing nano and micro-size tungsten powder.

2. Preparation of polymer composites

Completing polymer composites start from preparing the base polymer matrix. The base polymer matrix consists of blending high density polyethylene (HDPE, Honam Petrochemicals Corp.), ethylene propylene monomer (EPM, KEP 020P, ethylene content ~71 wt%, Kumho Polychem) with 3:7 weight ratios respectively and a small amount of cross-linking agent tribally cyanurate (TAC, ~1 wt%). Micro-sized tungsten powder (~25.4μm, Taegu Tac, Korea) was selected for radiation shield applications and mixed with the base polymer matrix ($HDPE_{30}EPM_{70}$) to complete polymer composites. The polymer composites containing 7.5 wt% and 15% wt% micro-sized tungsten were completed. The nano-sized tungsten powder was prepared using ball milling processes. About 20g of tungsten powder, 100g tungsten carbide (WC) balls, and 0.1g low density polyethylene were inserted each milling jar and milled together for 6 hours at 600 rpm in planetary mill (Taemyung Corp. Korea). The sized of milled tungsten were confirmed using SEM as shown in Fig. 1. The polymer composites containing 7.5 wt% and 15% wt% nano-sized tungsten were also completed. As shown in Fig. 2, the composites containing nano-sized tungsten powder has darker color than the composites containing mocro-sized powder.

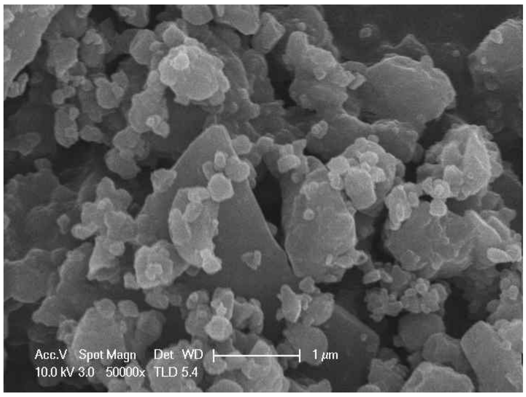

Fig 1. SEM image of milled tungsten powder

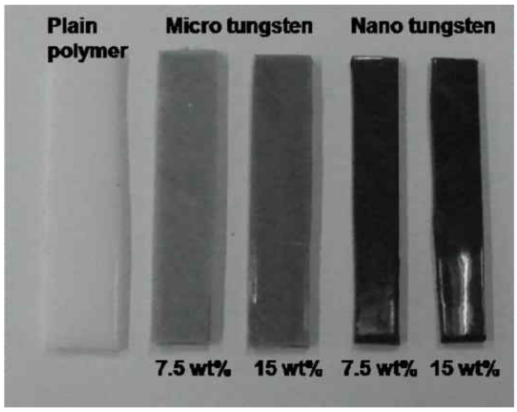

Fig 2. Completed polymer composites containing 7.5 wt% and 15 wt% micro/nano-sized tungsten powder

The dispersion of tungsten micro/nono-particles in polymer was observed using scanning electron microscope (SEM, Sirion, FEI Netherlands). As shown in Fig 3, the both micro/nano-particles (white dots) dispersed well in the polymer. Although we can observe that some particles agglomerated together, especially tungsten nano-particles, the agglomeration is ignorable and most of particles dispersed perfectly in the polymer.

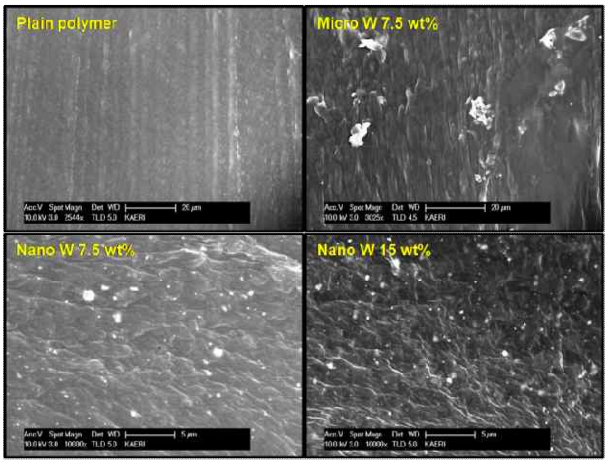

Fig 3. SEM images of polymer composites

3. Mechanical properties experiments

The tensile stress and elongation at break were measured using universal testing machine (Model # : WL2100, Withlab, Korea). The tests were conducted for two groups of samples, neat samples and irradiating electron beam (E-beam) samples. About 150 kGy E-beam irradiated to the polymer composites to improve mechanical properties. Fig 4. and Fig 5. Show the results of tensile strength and elongation at break respectively.

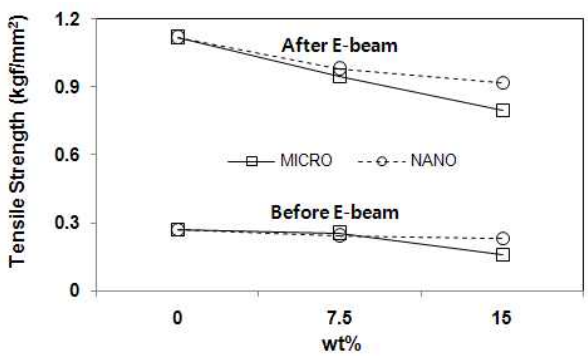

Fig 4. Results of average tensile strength

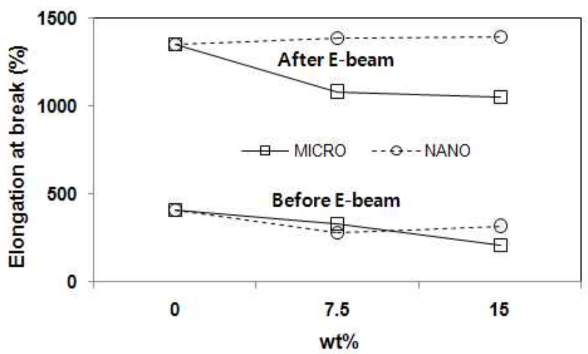

Fig 5. Results of average elongation at beak

The values of mechanical properties, both tensile strength and elongation, change depending on wt% of tungsten powder in the polymers. However, nano-powder composites has higher the tensile strength and elongation at break than micro-powder composites, especially 15wt% case. This means that the adhesion between particles and composite is strong because the surface of nano-sized tungsten powder modified during ball milling process. In addition, the mechanical properties much improved after E-beam irradiation.

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4. Conclusions

In this research, we observed the mechanical properties of polymer composites containing micro/nano-sized tungsten powder. We could conclude that the decreasing of mechanical properties can be protected using nano-sized powder. In addition, the mechanical properties much improved by irradiating E-beam. In particular, the elongation can be improved than neat-polymer composites by mixing nano-powder and by applying E-beam irradiation. Based on these results, the polymer composites containing nano-sized powder may be applied for radiation shield by mixing with various wt% of tungsten.

Acknowledgement

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