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Fabrication and characterization of UAl_x intermetallic compounds

Ji Min Nam, Moon Soo Sim, Ho Jin Ryu*, Se Jung Jang, Jong Man Park
Korea Atomic Energy Research Institute: 1045 Daedeok-daero, Yuseong-gu, Daejeon 305-353, Republic of Korea
**Corresponding author: hjryu@kaeri.re.kr*

1. Introduction

Currently, uranium aluminum alloys have been used as dispersion fuel in research reactors [1] and U-Al dispersion targets for ^{99}Mo medical radioisotope production [2]. One of the conventional manufacturing processes of the U-Al dispersion fuels and targets is the grinding and crushing of cast UAl_2 ingot by mechanical methods. Also, produced powder was mixed with Al [3]. However, it is complicated and inefficient to fabricate U-Al. Therefore, KAERI has produced U-Al powder with varying Al content using a centrifugal atomization method [4].

In this study, U-Al alloy and UAl_x intermetallic compound powders were produced by a centrifugal atomization method. The atomized powders were characterized be X-ray diffraction, SEM, EDX, and density measurements.

2. Experimental procedures

U-1wt%Al, U-10wt%Al and U-20wt%Al alloy powders were fabricated in this experiment. Superheated molten uranium-aluminum was fed through a small nozzle onto a graphite disk spinning at about 30,000 rpm, and liquid alloy droplets were then spread from the disk by a centrifugal force and cooled in an argon atmosphere. Fig. 1 shows the fabrication steps for the atomized U-Al powders. This method has advantages such as a single-step process, short processing time, a high production yield rate, high purity with less defects, and spherical formation for easy dispersion plate fabrication.

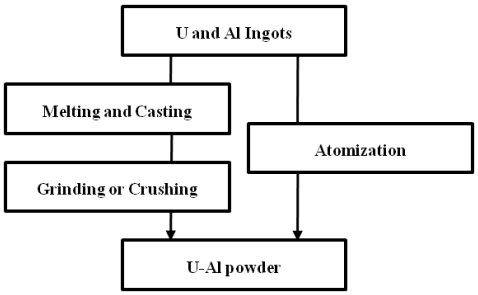


Fig. 1. Step for the fabrication of powders.

The microstructures of U-Al powders were observed by scanning electron microscopy (SEM). X-ray diffraction and Energy dispersive x-ray spectroscopy (EDX) experiments were performed to characterize the UAl_x.

3. Results and discussion

The differences in powder microstructures in accordance with aluminum content were compared, as shown in Fig. 2(a-c). Typical solidification microstructures were developed in rapidly solidified spherical powders. Fig. 2(a) shows the spherical morphology of the atomized U-1wt%Al particles and a cross-section image. The fine grain structure is evident. The boundaries of U and UAl_2 were observed in U-10wt%Al, as shown in Fig. 2(b). Fig. 2(c) shows the equiaxed zone starts from one part of a liquid droplet, and then a columnar zone develops along the thermal flow direction. Columnar dendrite growth of UAl_2 was observed in U-20wt%Al.

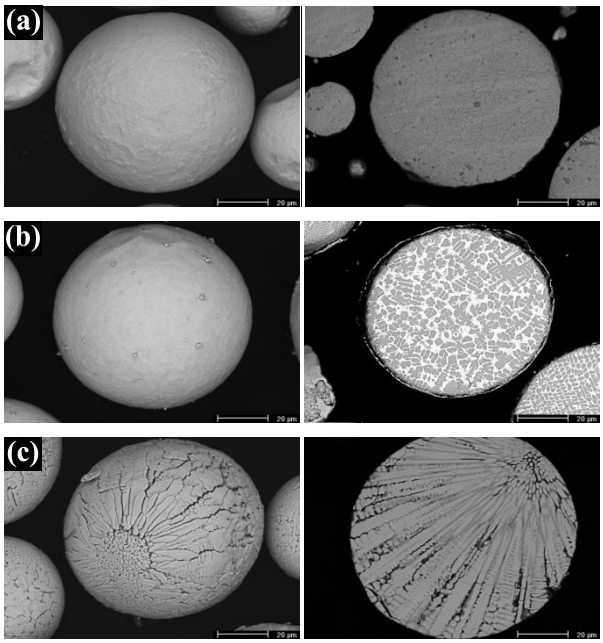
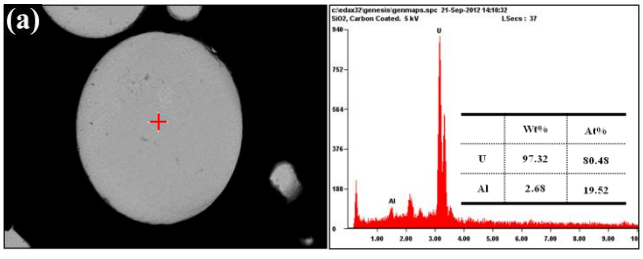


Fig. 2. Spherical morphologies and cross-section SEM images of atomized particles : (a) U-1wt%Al, (b) U-10wt%Al, (c) U-20wt%Al

EDX analyses, as in Fig. 3, show that U-10wt%Al is composed of uranium and UAl_2, and U-20wt%Al consists of UAl_2 and UAl_3.



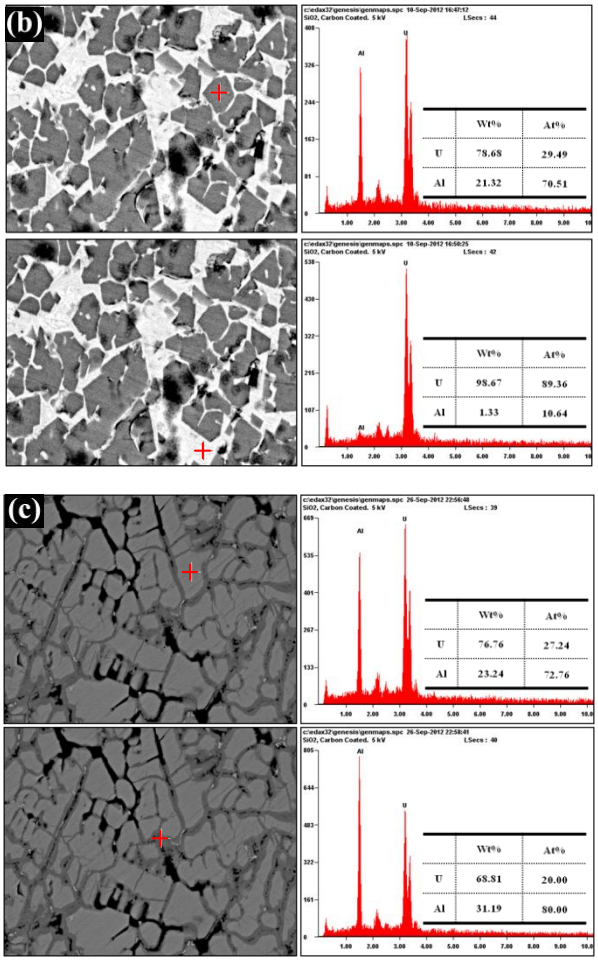


Fig. 3. Cross-section SEM images and EDX spectra of atomized particles : (a) U-1wt%Al, (b) U-10wt%Al, (c) U-20wt%Al

XRD patterns of the particles are shown in Fig. 4. It was observed that the compounds of U-Al were composed of UAl_2 and UAl_3 in U-10wt%Al and U-20wt%Al. However, a UAl_3 pattern could not be found in U-1wt%Al.

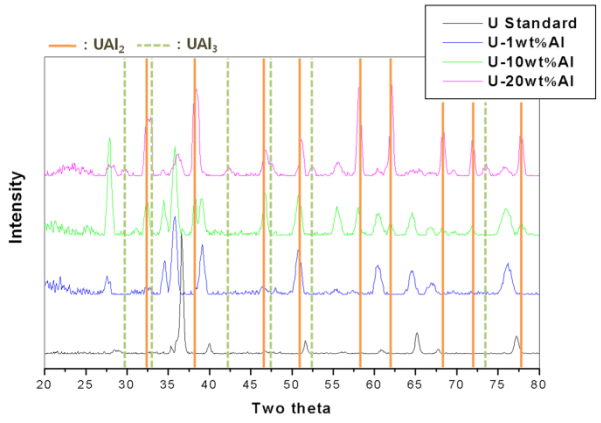


Fig. 4. X-ray diffraction patterns of U and U-Al powders.

4. Conclusions

1. Atomized U-Al powders with compositions of U-1wt%al, U-10wt%Al, U-20wt%Al were fabricated.
2. XRD analyses identified UAl_2 and UAl_3 intermetallic compounds formed in the atomized particles.

ACKNOWLEDGMENTS

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