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Fabrication of Atomized Uranium Dispersion Targets for Fission Mo Production

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1. Introduction

Among radioisotopes for medical diagnosis, Tc-99m is most widely used. Mo-99 produced from nuclear fission of uranium in research reactors is the key radioisotopes for Tc-99m generators. Generally, major producers of Mo-99 still use targets containing highly enriched uranium (HEU). However, the international non-proliferation policy emphasizes the minimization of the use of HEU in medical radioisotopes production nowadays[1]. Therefore, low enriched uranium (LEU) targets have been developed by casting and crushing of UAl_2 compounds. The UAl_2 particle dispersed target has a lower U-235 density when compared to HEU targets. In order to improve the low production efficiency of LEU targets, target designers try to develop high uranium density targets with LEU. KAERI has proposed that high density uranium alloys, instead of UAl_2, can be used as dispersing particles in an aluminum matrix[2]. While it is very difficult to fabricate uranium alloys powder by grinding or crushing, spherical powder of uranium alloys can be produced easily by centrifugal atomization[3].

Mini-size targets with 3, 6, and 9 g-U/cc were fabricated in this study to investigate the feasibility of high density targets with atomized uranium particles. The microstructural changes after thermal treatments were observed to analyze the interaction behavior of uranium particles and aluminum matrix.

2. Experimental procedures

Atomized spherical uranium powder and pure aluminum powder were mixed and compacted to form dispersion targets with 3, 6, and 9 g-U/cc. The mixed powder compacts were sandwiched between 6061Al plates and hot rolled into target plates with a thickness of 1.5 mm at 500°C. Blister tests were conducted at 485°C for 1 hour to check the bonding integrity of the dispersion targets. Cross-sectional microstructures of the fabricated targets were observed by scanning electron microscopy. Additional heat treatments were applied to the targets for further reaction of the uranium particles and the aluminum matrix at 700°C for 1 to 4 hours. The variations of volume fractions of UAl_x after annealing were measured by image analysis. The dissolution behavior of the heat treated dispersion targets in $NaOH/NaNO_3$ solution was observed to check the feasibility of alkaline digestion of uranium particle dispersion targets.

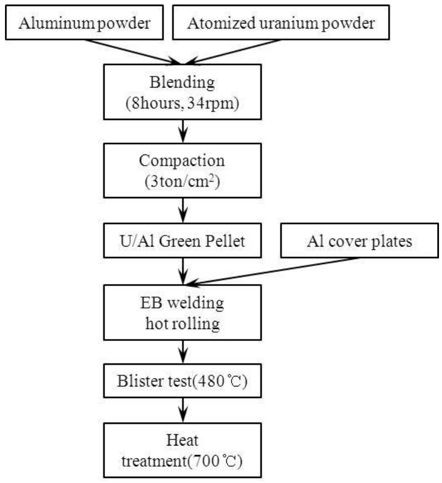


Fig. 1. Flow chart for the preparation of UAl_x-Al dispersion target plates.

3. Results and discussion

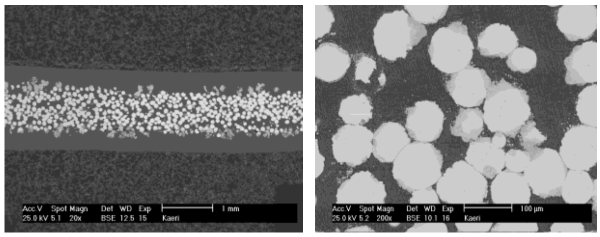


Fig. 2. SEM micrographs for an as-rolled 6 g-U/cc target

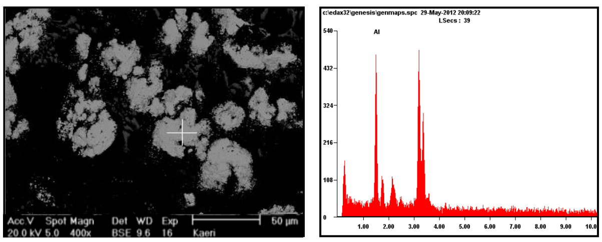
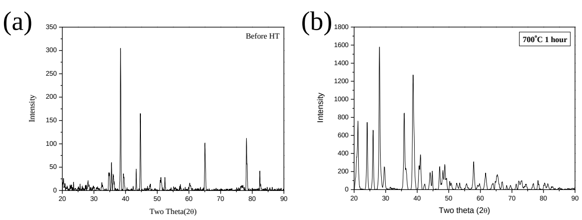


Fig. 3. An SEM micrograph and its EDS spectrum for a 3 g-U/cc target after annealing at 700°C 1 hour.



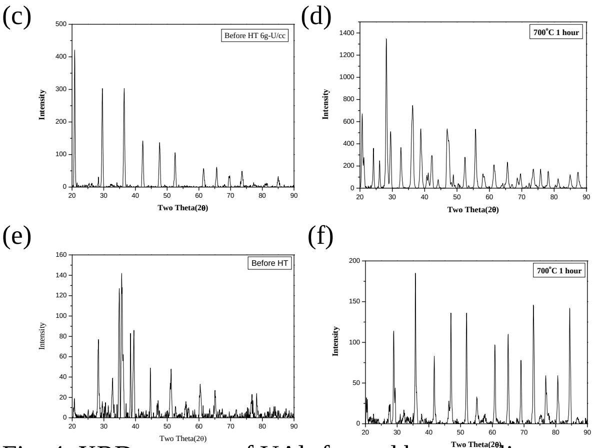


Fig. 4. XRD patterns of UAl_x formed by annealing (a),(b)3g-U/cc (c),(d)6g-U/cc, (e),(f)9g-U/cc, (b),(d),(f) heat treated at 700℃ for 1 hours

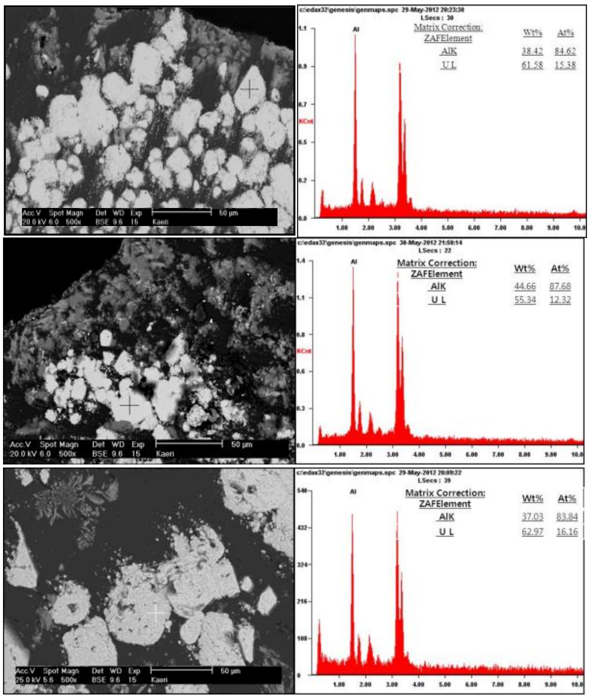


Fig. 5. SEM micrographs and their EDS spectrum showing the variation of U-Al composition with increasing annealing time(1,2,4 hours)

The transverse cross-section image of a 6g-U/cc mini -size target was shown in Fig. 2. The mini-size target was fabricated successfully by using hot rolling method and had 1.5mm thickness of the included UAl_x powders. Also, annealing was performed after hot rolling at 500℃ and had a thickness of 1.5mm. The agglomeration of UAl_x could not be founded.

The microstructure of 3g-U/cc mini-size target after heat treatment at 700℃ was observed by scanning electron microscopy in fig. 3. The EDS result shows that UAl_x interaction layers were created between uranium particles and aluminum matrix.

Fig. 4 shows XRD patterns obtained after the heat treatment at 700℃ for 1hour. Growth of UAl_3 and UAl_4 was observed at 3, 6, 9g-U/cc heat treated samples

The dispersion targets were annealed at 700℃ for 1, 2, 4 hours, and EDS analyses were performed as shown in Fig. 5. It was confirmed that uranium particles reacted with the aluminum matrix. The variation of UAl_x composition is not much among the heat treated samples, because uranium particles and aluminum were reacted thoroughly in 1hour.

A preliminary dissolution test using $NaOH/NaNO_3$ solution of the heat treated uranium particle dispersed targets showed that uranium particle dispersion targets can be dissolved in alkaline solutions after forming UAl_x by a heat treatment.

4. Conclusions

- Mini-size dispersion target with atomized uranium particles up to 9 g-U/cc were fabricated by hot rolling at 500 ^oC.
- Atomized uranium particles react with the aluminum matrix to form UAl_x phases during fabrication processes.
- Most of the uranium particles in the dispersion targets were converted to UAl_x after annealing at 700^{o}C.
- Alkaline dissolution of uranium particle dispersed targets was conducted by using $NaOH/NaNO_3$ solution.

ACKNOWLEDGMENTS

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