

Thermal Properties Evaluation of U-Zr and U-Zr-Ce Alloys

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1. Introduction

Even if thermal properties such as specific heat, thermal expansion and thermal conductivity for metallic fuels in SFR (Sodium-cooled Fast Reactor) are very important, few experimental data is available [1, 2]. In this paper, some experimental data on thermal properties such as specific heat and thermal expansion are presented.

2. Experimental Part

U-XZr binary alloys(X=10, 15) and U-10Zr-YSm ternary alloys(Y=4, 6) were employed as the metallic fuel specimens for thermal properties evaluation. All the alloys were fabricated by injection casting method [3]. All the specimens are disk-type shape with a thickness of 2 mm for specific heat measurement and 10 mm for thermal expansion measurement, respectively.

3. Results

Specific heat and thermal expansion characteristics were evaluated for U-Zr binary alloys and U-Zr-Ce ternary alloys in the temperature range from 25 to 630°C to characterize the thermal properties of SFR fuel. The experimental results are shown in the Fig. 1, 2, 3, 4, and 5. Fig. 1 shows specific heat changes of U-10Zr, U-15Zr, U-10Zr-4Ce, and U-10Zr-6Ce alloys with increasing temperature. Fig. 2, 3, 4 shows the thermal linear expansion behaviors of these alloys with increasing temperature

The important results are drawn as follows.

First, specific heats of Ce-containing U-10Zr-Ce alloys were higher than those of U-10Zr and U-15Zr alloys above 400°C, which means that Ce element in the fuel can play an important role to increase specific heat of the fuel.

Second, thermal expansion of U-Zr binary alloys and U-Zr-Ce ternary alloys increases linearly with increasing temperature. Alloying effect analysis shows that addition of Zr element in the fuel decreases thermal expansion of the fuel, whereas addition of Ce element in the fuel increases thermal expansion of the fuel.

Third, There is a transition of thermal behavior in the temperature range of about from 600~700°C, which is believed to be caused by phase transformation of the fuel materials.

4. Conclusion

On the basis of specific heat and thermal expansion characteristics results of U-Zr binary alloys and U-Zr-Ce ternary alloys, the following conclusions are drawn.

First, The element, Ce, in the fuel seems to increase specific heat of U-Zr-Ce alloy system.

Second, addition of Zr element in the fuel decreases thermal expansion of the fuel, whereas addition of Ce element in the fuel increases it in U-Zr-Ce alloy system.

Reference

- [1] D. C. Crawford *et al.*, "Fuels for sodium-cooled fast reactor : US perspective", *Journal of Nuclear Materials*, 371, 2007.
- [2] J. Carmack *et al.*, "Advanced Sodium Fast Reactor (SFR) Fuel Comparison", *GEN IV International Forum*, April, 2008.
- [3] C. L. Trybus *et al.*, "Casting of metallic fuel containing minor actinide additions", *Journal of Nuclear Materials*, 204, 1993.

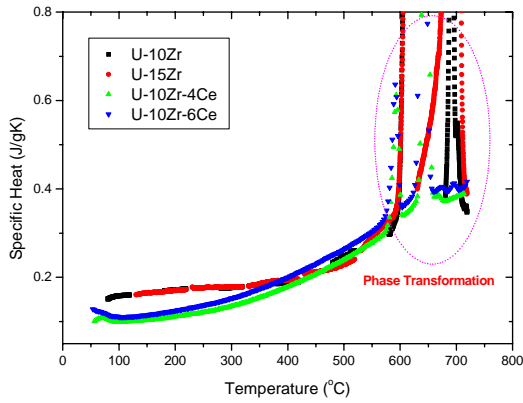


Fig. 1. Specific heats with increasing temperature of U-Zr binary alloys and U-Zr-Ce ternary alloys

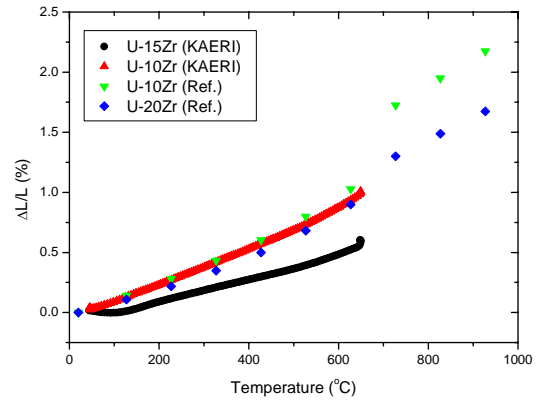


Fig. 4. Thermal expansion with increasing temperature of U-Zr binary alloys

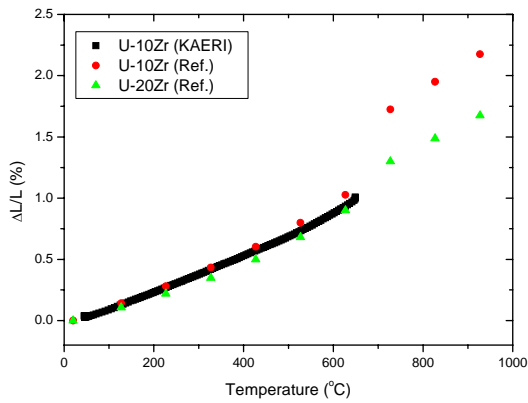


Fig. 2. Thermal expansion with increasing temperature of U-10Zr binary alloy

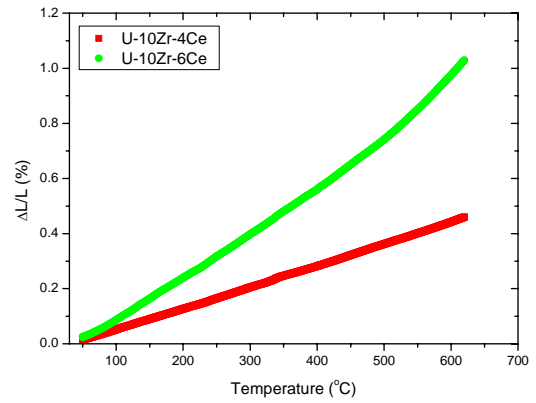


Fig. 5. Thermal expansion with increasing temperature of U-Zr-Ce ternary alloys

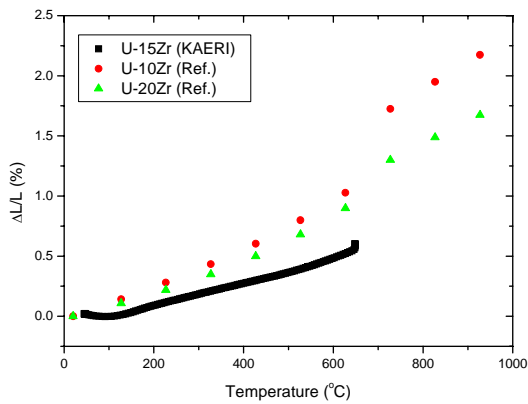


Fig. 3. Thermal expansion with increasing temperature of U-15Zr binary alloy