SEM-EDS and XRD study on the metallic Mo-doped CeO_2

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1. Introduction

Spent nuclear fuel (SNF) is a complex, heterogeneous system in terms of its chemical composition and microstructure because of many fission products. Among them, ε-particles such as Mo, Ru, Ru, Pd, and Tc in SNF, are not included in the crystal lattice of UO_2 but are found in boundaries trapped in pores [1].

It is known that ε-particles could affect on structural change and chemical reactivity of UO_2. For example ε-particles has an important role for oxidation/corrosion of UO_2 [2].

In this study, Mo-doped CeO_2 was prepared as a simulated spent fuel and studied to understand the effect of ε-particles on physicochemical properties of spent fuel. Scanning electron microscope (SEM), energy-dispersive X-ray spectroscopy (EDS), and X-ray diffraction (XRD) were used to characterize Mo-doped UO_2 and optimize the preparation process of the target sample.

2. Experimental

The CeO_2 (99.995%, Sigma Aldrich) and powders MoO_2 (99%, Sigma Aldrich) powders were used to make the samples. CeO_2 and MoO_2 powders were mixed and pelletized (MoO_2 was weight as 0, 1, 3, and 5 wt%). The sample pellets were sintered in the tube furnace at 1200℃ for 18h with 4%H_2/Ar atmosphere. The surface morphologies and elements analysis of prepared pellets were observed by SEM (JEOL, USA) and EDS (JEOL, JSM-6610LV), respectively. XRD (Bruker, D8 Advance) data were obtained by Bruker D8 Advance system in the 2θ range of 5°to 120° with a scanning step of 0.02°/0.1s. Cu Kα line source (beam current 40mA at 40Kv) was used for XRD analysis in room temperature.

3. Results and Discussion

Fig.1 shows the SEM image and EDS mapping of the sample. In the SEM image, red dots indicate the Mo element. The component analysis shows that MoO_2 reduced to Mo after sintering under reducing conditions. Fig. 2(a) shows XRD patterns of a let Mo-doped CeO_2 pellet. Main peak at 28.6° was matched with cubic CeO_2, The shoulder peak at 28.3° in left side of the main peak, was matched with cubic $Ce_{11}O_{20}$. However, in Fig. 2(b), you can see that the shoulder peak at 28.3° disappears. It seems that $Ce_{11}O_{20}$ formed during sintering under reducing condition is oxidized in the atmosphere for a long time. The peaks at (a) 40.6° and (b) 40.6° were matched with cubic Mo. It was confirmed that the Mo oxide was reduced to metallic Mo. It seems that metallic Mo particles were preserved in the atmosphere for 20 days.

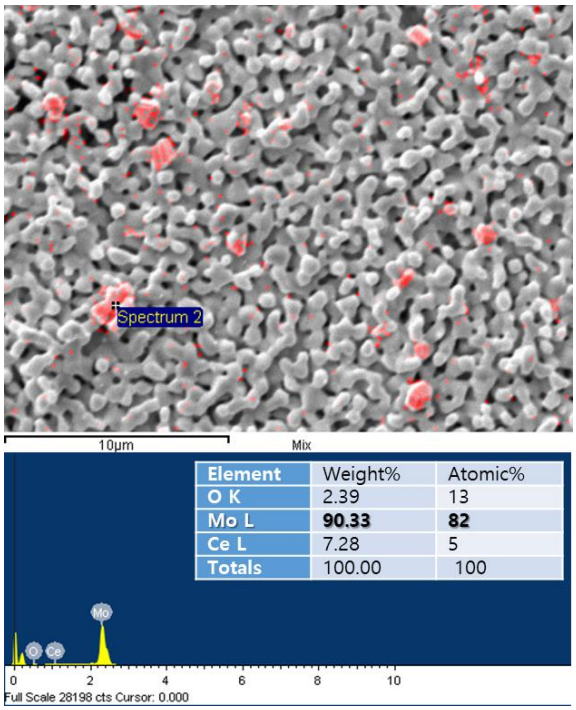

Fig. 1. (Up) SEM image of $Ce_{0.95}Mo_{0.05}O_2$ (bottom) EDS result of the point indicated as the "spectrum2".

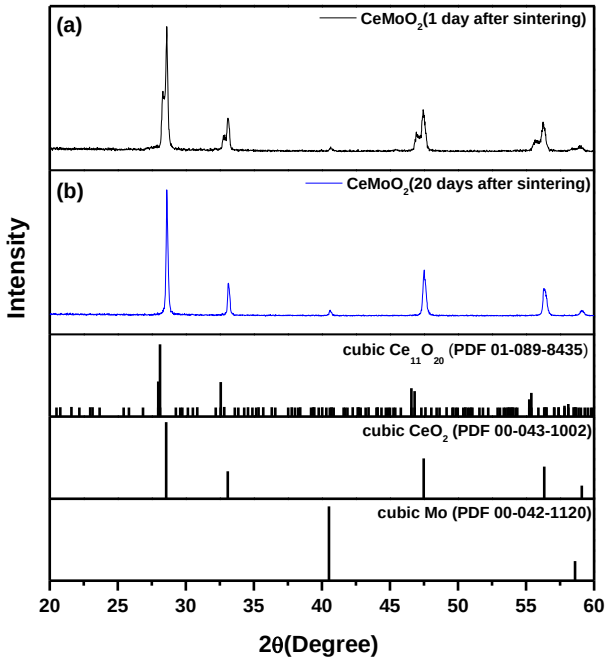

Fig. 2. XRD patterns for (a) 1 day, and (b) 20 days $Ce_{0.95}Mo_{0.05}O_2$ after sintering.

4. Conclusions

Metal Mo-doped CeO_2 was characterized through SEM-EDS and XRD. It was confirmed that the sample, kept in the atmosphere during 20 days after sintering, has cubic CeO_2 structure and Mo metal particle in CeO_2 matrix. We will optimize the manufacturing process to obtain perfect Mo-doped CeO_2 with a short and simple preparation process. We will study additional physical properties of Mo-doped UO_2 to understand how ε-particles affects on the structure and chemical reactivity of CeO_2.

REFERENCES

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