Characterization of Uranium Oxides by FTIR

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1. Introduction

Generally, X-ray diffraction (XRD) analysis or thermogravimetry (TG) have been used for the characterization of the uranium oxide phases, but sometimes depending on the complexity of samples more information by other analytical techniques is needed for the clear determination. In this work, the measurement of Infrared (IR) spectra for Gd-doped UO_2 including pure UO_2 and their oxidized products were carried out in order to investigate the applicability of Fourier Transform infrared (FTIR) measurement for the characterization of uranium oxide species.

2. Experimental

2.1. Preparation of Gd-doped UO_2

The samples of $(U_{1-y}Gd_y)O_2$, where y ranged from 0 to 0.8, were prepared by sintering in hydrogen atmosphere at 1,700℃ for 4 hours. The pellets were finally pulverized in an agate mortar for the measurements.

2.2. Preparation of oxidized samples of Gd-doped UO_2

The prepared samples of $(U_{1-y}Gd_y)O_2$ were heated under air atmosphere for 1 hour at 550℃. This temperature was chosen from the thermogravimeric curves where no further weight gains by oxygen occurred. After cooling, FTIR measurements were carried out.

3. Results and discussion

3.1. Spectra for the undoped UO_2 and U_3O_8

Fig. 1 shows each of FTIR spectra for the undoped UO_2, U_3O_8 and the dopant, Gd_2O_3. As shown in Fig. 1, there is no specific peak for the UO_2, on the other hand the peaks of 487cm^{-1}, 517cm^{-1}, 712cm^{-1} for the U_3O_8 and 434cm^{-1}, 537cm^{-1} for the Gd_2O_3 are found.

3.2. Spectra for the Gd-doped uranium oxides

Fig. 2 shows the FTIR spectra for the Gd-doped UO_2 including the spectra of pure UO_2 and Gd_2O_3 for comparison. The spectra in the range(y=0.11 to 0.42) look almost alike with the undoped UO_2 showing no specific peak, but those where y is above 0.42 show some variation deviating from the trend of the preceding ones. And the peaks(434, 537cm^{-1}) for pure Gd_2O_3 are not found in the spectra for the Gd-doped UO_2. These results are in accord with the result of previous work[1], that is, UO_2 and Gd_2O_3 form a solid solution, $(U_{1-y}Gd_y)O_2$ in the range(y=0 to 0.42), which was resulted by plotting the lattice parameters of $(U_{1-y}Gd_y)O_2$ against y(Fig. 4.) and applying Vegard's law[2].

Fig. 3 shows the FTIR spectra for the oxidized products of the Gd-doped UO_2. As shown in Fig. 3, the peaks of 487cm^{-1}, 517cm^{-1} for U_3O_8 disappear and the peak of 712cm^{-1} decreases when y is 0.11. And the spectra where y is above 0.11 does not show any peaks for U_3O_8.

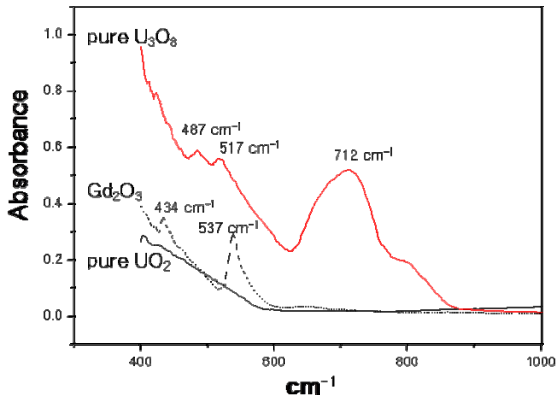

Fig. 1. FTIR spectra for the undoped UO_2 and U_3O_8.

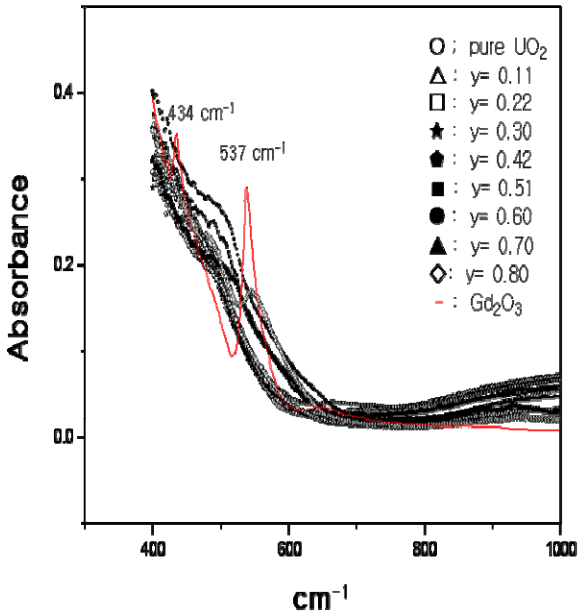

Fig. 2. FTIR spectra for the samples of Gd-doped UO_2 $[(U_{1-y}Gd_y)O_2]$.

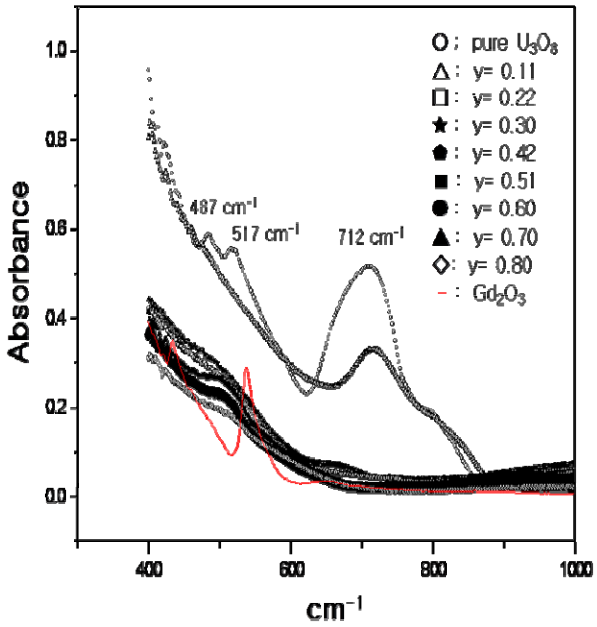

Fig. 3. FTIR spectra for the oxidized products of the Gd-doped UO_2 [$(U_{1-y}Gd_y)O_2$].

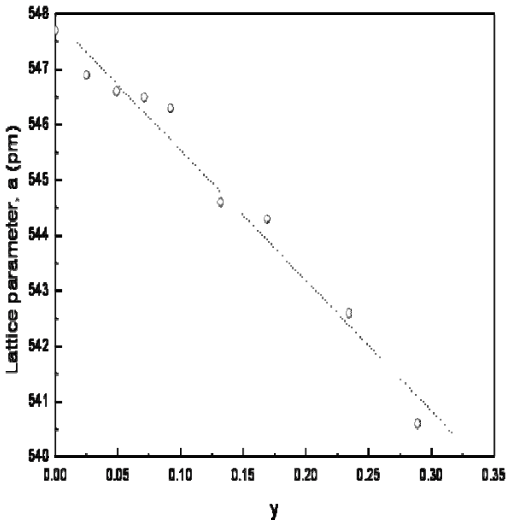

Fig. 4. Lattice parameter of $(U_{1-y}Gd_y)O_2$ versus Gd content (y) in $(U_{1-y}Gd_y)O_2$ at a room temperature[1].

4. Conclusion

Through the spectra of U_3O_8, oxidized products of the Gd-doped UO_2 and Gd_2O_3 of this work, it was known that the specific absorption peaks corresponding to M-O vibrations of these uranium oxides and the inorganic dopant, Gd_2O_3 are distributed in the range from 400 cm^{-1} to 1000 cm^{-1}. Consequently, the applicability of FTIR as an auxiliary method with XRD for the characterization of uranium oxide species was confirmed.

REFERENCES

[1] J. G. Kim, Y.K. Ha, S.D. Park, K.Y. Jee, W.H., J. Nucl. Mater. 297 (2001) 327
[2] A.R. West, "Basic Solid State Chemistry", JOHN WILEY & SONS, 1991, p253