uranium desorbed into the solution was determined after shaking for certain time. Desorption efficiency was calculated directly from the difference between the desorbed and absorbed uranium. The desorption ratio (%) was calculated by the following equation:

$$\text{Desorption}(\%) = \frac{\text{Amount of } U(\text{VI}) \text{ desorbed}}{\text{Amount of } U(\text{VI}) \text{ adsorbed}} \times 100\%$$

As it is shown in Table 1, HNO_3 was the best desorption reagent and the influence of HNO_3 concentration for desorption was also investigated. The results suggested that HNO_3 concentration had no obvious influence on uranium desorption when it is greater than 0.1 mol/L. 0.1 mol/L HNO_3 was the best desorption solution for uranium desorption with desorption ratio of 62%. More efficient desorption reagent is desired in the future work.

Table 1 Desorption of uranium with different desorbing agents.

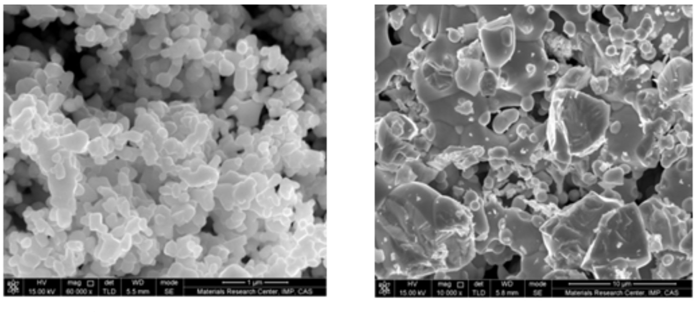
Agent	Concentration / (mol/L)	Desorption / %
HNO_3	0.05	54.07
HNO_3	0.10	62.10
HNO_3	0.25	62.86
HNO_3	0.50	61.78
Na_2HCO_3	0.10	38.78
Na_2CO_3	0.10	4.89
NaOH	0.10	6.06

2 - 38 Separation of Rare Elements from Spent Nuclear Fuel

Fan Fangli and Qin Zhi

Rare-earth (RE) elements (La, Ce, Pr, Nd, Pm, Sm, Eu, Gd and others) are produced in nuclear fuel by uranium fission and by the decay of other fission products. Rare-earth (RE) elements in spent nuclear fuel are strong neutron absorbers, which affect the fission efficiency of fissile materials and decrease the thermal conductivity of the UO2 matrix. Thus, to enhance the thermal conductivity and nuclear energy production of reused fuel, the separation of RE elements from spent nuclear fuel is very necessary.

In the present work, the separation of rare-earth elements from simulated spent fuel by high temperature oxidation was investigated. Samples of U_3O_8 doped with varying quantities of RE (where RE was Nd or Sm) were prepared by the co-precipitation method. Ammonium hydroxide (25%) was used to co-precipitate neodymium and uranium from a solution of their nitrates. The resulting Nd-doped ammonium diuranate (ADU) was collected by centrifuging, and then was washed several times with dilute ammonium hydroxide before being air-dried at 100 °C. The ADU powders were then heated in air at 900 °C for 4 h to covert then to U_3O_8. The resulting $(U_{1-x}Nd_x)_3O_8$ powder as the starting material were carried out the heat treatment experiment in the temperature range between 1 000 °C and 1 700 °C for 6 h in air. Finally, the thermally treated powders were cooled to room temperature in air.



(a) 900 °C 4 h (b) 1300 °C 6 h

Fig. 1 (color online) SEM of the powders produced by the heat treatment of the $(U_{1-x}Nd_x)_3O_8$.

The samples after heat treatment were analyzed by SEM and XRD. Fig. 1 shows the SEM micrographs of the powders produced by the heat treatment of the $(U_{1-x}Nd_x)_3O_8$. From Fig. 1(a), one can see that the uniform small particles appeared in the starting material $(U_{1-x}Nd_x)_3O_8$. But after heat at 1 300 °C, the phase changed into two different particles. The small particles named as "rich-rare phase", $(U_{1-y}Nd_y)O_{2+v}$ particles were observed and most of them adhered to the side of the larger particle. The bigger particles was “poor-rare” phase, $(U_{1-z}Nd_z)_3O_{8-w}$. This result indicates that solid-state recrystallization of U_3O_8 occurred at 1 300 °C in our experiment, and suggests that secondary crystallization of RE-rich phase occurred concurrently with this recrystallization. The result of XRD also verified the new phase RE-rich phase appeared after heat treatment at 1 300 °C. And only U_3O_8 peak was found in the starting material. More detail investigation was underway in our laboratory.

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2 - 39 Manufacturing of Small Zirconia Kernels Using Improved Internal Gelation Process

Li Sa and Qin Zhi

Internal gelation method is a new method for the preparation of materials in wet chemical methods, which is used widely in superconducting materials, powder metallurgy, ceramic material, preparation of thin film and other material preparation, *etc.* The internal gelation process is an advanced production process for nuclear fuels. Its advantages include of avoiding particle dry preparation of dust controlling of gelation time and microsphere size, and homogeneous incorporation of fine particles of other materials into the microspheres. The traditional preparation of nuclear fuel core processes with cooled liquid material, by controlling the speed of the temperature of gelation[1]. By understanding the sol-gel chemical react principles, we proposed by adjusting the feed liquid molar ratio and composition, controlling gel react trend, simplifying the process equipment, the realization of room temperature without cooling step design process for preparing fuel core with driven pumps. This project mainly drives the feed liquid at normal temperature through with constant current pump to gelate without cooling devices. The process of using non cooling treatment, namely, maintaining constancy of liquid at room temperature, controlling gel process occurred in the hot oil against the realization of the traditional with simplified process flow, which was prepared for the nuclear fuel kernels by building a set of optimization of equipment process. The topic is about to the basic research work of preparing for fuel kernels with sol-gel process and its related nuclear chemistry.

Zirconium oxide microspheres were used as surrogates because zirconium and TRU microspheres from the internal gelation process are amorphous and encounter similar processing problems[2]. The process is basis on the precipitation of metal oxi-hydroxides and the thermal decomposition of the precipitate. The precipitation is achieved by the thermal acceleration of the nitric acid catalyzed decomposition of Hexamethylenetetramine (HMTA, $C_6H_{12}N_4$)and urea ($CO(NH_2)_2$). Ammonium Hydroxide is formed in a heated droplet of a mixed solution of nitrates, HMTA and urea[3]. The ammonium hydroxide causes the precipitation of the metal hydroxides and gelation. Urea, $CO(NH_2)_2$, is also added into the feed solution to obtain good mechanical property of the gel spheres Feed solution was prepared by dissolved zirconium oxychloride and deionized water in required proportion at room temperature[4]. The standard concentration for the HMTA (Fisher Scientific) and urea (Fisher Scientific) in the stock solution was 3.18 mol/L for each. The final feed solution with HMTA and urea to zirconium molar ratios of 0.9. After the microspheres were gelation in the hot silicone oil and were collected, then they were aged in 12.5% ammonium hydroxide, washed with carbon tetrachloride and washed with 0.5 mol/L NH_4OH in steps, and air-dried at ambient temperature[4].

Finally, we had successfully manufactured zirconium kernels in the diameters of 1 mm with the reproved gelation equipment. The next works are refers to the relatively modifications were made to an existing internal gelation system[5].

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