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UO_3 Intermediate Particle Preparation Using the Sol-Gel Process

K-C Jeong, Y-K Kim, S-C Oh, M-S Cho, Y-W Lee, and J-W Chang
Hydrogen Production Technology Team, Korea Atomic Energy Research Institute
150 Dukjin-dong, Yusong-Gu, Taejon, Korea, 305-353
kcjeong@kaeri.re.k

1. Introduction

In general, the Pebble or Prismatic type fuel, which was fabricated with a spherical ceramic UO_2 kernel particles, is inserted into the HTGR(High Temperature Gas Reactor). The UO_2 kernels obtained from a sol-gel method changed to a TRISO(TRISOtropic) shape[1,2]. The TRISO-shaped fuel particle : UO_2 kernel spheres coated with layers of porous pyrolytic carbon(PyC), inner dense PyC, silicon or zirconium carbide(SiC, ZrC), and outer dense PyC. Sol-gel technology is a promising way to prepare the spherical UO_2 kernel because of its merits of a high density of the UO_2 powder and easily controlled the components[3].

There are two kinds of sol-gel methods, internal and external chemical gelations. UO_3 gelation can be accomplished either externally via ammonia gas and ammonium hydroxide or internally via an added ammonia generation medium such as HMTA. In this study, firstly we carried out the feasibly study on the preparation of spherical UO_3 gel particles with the internal and external methods which used the ADUN solution, and compared with the characteristics of the UO_3 gel particles prepared with two different procedures, an internal and an external gelation[3,4].

2. Experimental

The spherical UO_2 kernel preparation experimental apparatus mainly consists of the broth solution strorage tank, droplet nozzle, gelation column, and a heating/ cooling system, as shown in Figure 1.

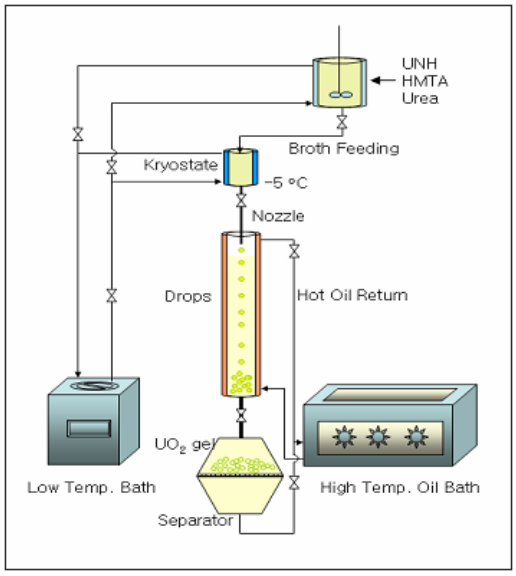


Figure 1. Experimental apparatus.

The broth solution is prepared with ADUN(Acid Deficient Uranyl Nitrate), urea, poly vinyl alcohol, and THFA solution. And the droplets of the broth solution was made through a nozzle system attached at the top of the gelation column. Also, the ADUN solution was obtained from the dissolution of U_3O_8 powder with the concentrated HNO_3. The UO_3 gel particles can be obtained from an internal or an external gelation of the broth solution. Particle characteristics were analyzed with stereoscope, X-ray, and FT-IR.

3. Results and Discussion

3.1 pH profile of broth solution

Broth solution in this study was obtained from a mixing of an ADUN solution and urea at first. And then this solution was mixed with PVA in order to increase the viscosity, and finally added to the THFA solution for supporting the PVA characteristics. Total mixing time of all the materials was below one day.

The pH profile obtained at a mixing of ADUN, urea, PVA, and THFA solution is plotted in Figure 2.

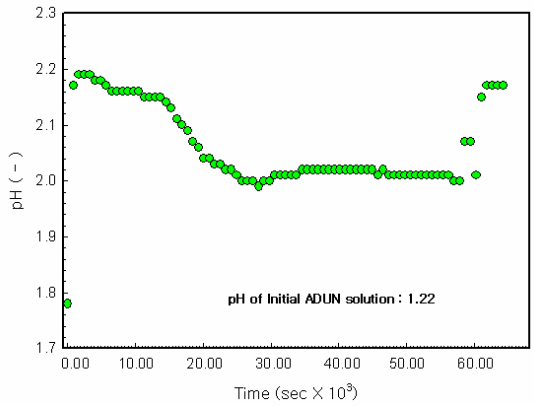


Figure 2. A pH profiles obtained during the mixing of ADUN, urea, and THFA solutions.

The pH value of the initial ADUN solution showed about 1.22, and this value increased to 2.2 at the initial stage when added to the 8M urea solution. And then, the pH value decreased to 2.0 according to a passing of the mixing time, in this time, the ammonia and carbonate was released from dissolution of the urea. When the THFA solution was added to this solution, the pH value of the final broth solution was increased to

about 2.2 again. This final solution was used as the broth solution of the uranium material for the UO_3 gel particles preparation.

3.2 Spherical UO_3 gel particle preparation

The spherical droplet is formed by dropping the broth solution from a nozzle into air/ammonia and organic liquid. Spherical drops form from the effect of a surface tension before an exposure to the gelation of the broth droplet. At interface of a gas-liquid, and a break of the spherical form may occur. In general, the starting solution is heavy metal nitrate, and the additives and polymer are added into this solution. Figure 3 showed the simple schematic flow diagram of the UO_2 kernel preparation.

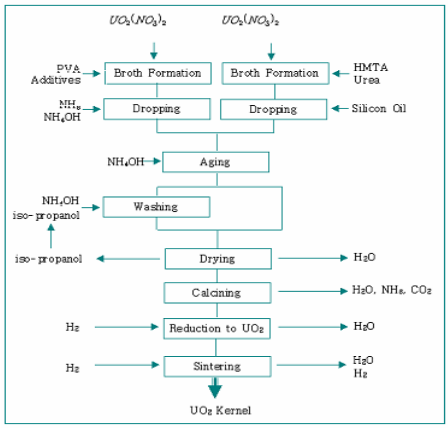
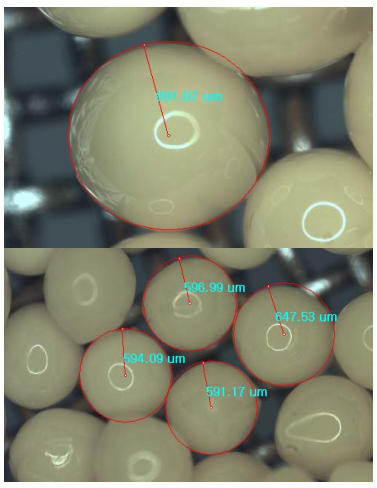


Figure 3. Internal and external gelation method.

In the UO_3 gel particle preparation as shown in Figure 3, the acid deficient state of the ADUN solution was very important[1]. If the acid deficient state in the UN solution was not achieved, the property of the forming spherical UO_3 gel particle became a crystalline state. In this case, theoretical density from these particles could not obtain the required value. In this study, we used the ADUN solution with $[NO_3^-]$/U mole ratio 1.75.



X 40

Figure 4. UO_3 gel particles obtained from external gelation method.

Figure 4 shows the SEM pictures of the UO_3 gel particles obtained from the external gelation procedure of this study. A perfect spherical UO_3 gel particle was not obtained. But we could obtain the spherical UO_3 gel particles from more experiments and better conditions.

4. Conclusion

In this study we mentioned the UO_3 gel particles preparation method with an external gelation procedure. From this study, we obtained the following results; 1) external chemical gelation procedure is a suitable method in the UO_3 gel particles production, 2) the initial state control of the broth solution is a very important factor for the spherical shape formation of the UO_3 intermediate gel particle and for a high density of the final UO_2 particles.

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ACKNOWLEDGEMENT

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