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Fission Product Release from TRISO by Diffusion

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1. Introduction

The high temperature gas-cooled reactor (HTGR) that is the likeliest Gen-IV uses the tri-isotropic coated particle. The TRISO-coated fuel particle is consisted of a micro-spherical kernel of oxide or oxycarbide fuel and coating layers of porous pyrolytic carbon (PyC), inner dense PyC (IPyC), silicon carbide (SiC) and outer dense PyC (OPyC). The function of these coating layers is to retain fission products within the particle. The SiC coating layer gives mechanical strength to the particle and acts as a barrier to the diffusion of metallic fission products which diffuse easily though the IPyC coating layer.[2]

In this study, final objective is analysis of fission product release during sever accident. Goal of this report is analysis of fission product release by diffusion as the first step.

2. Analysis of fission product release

1-D simulator analyze the fission product release.

2.1 Simulator model

Simulator calculates the concentration of fission product. Let's assume the simplest hollow sphere case.

$$F = \frac{3b(b-a)}{a^2}\left\{\frac{Dt}{(b-a)^2} - \frac{1}{6} - \frac{2}{\pi^2}\sum_{n=1}^{\infty}\frac{(-1)^n}{n^2}\exp(-Dn^2\pi^2 t/(b-a)^2)\right\}$$

2.2 Validation

Fig.1 shows the simulation results about the fractional release. After breakthrough time, fractional release is increasing.

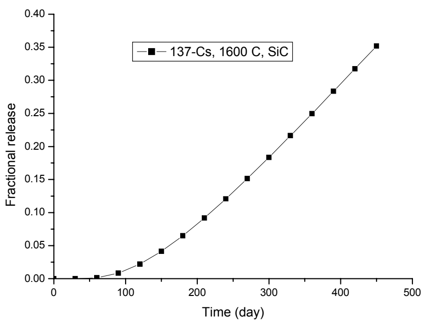

Fig. 1. Prediction of fission product release

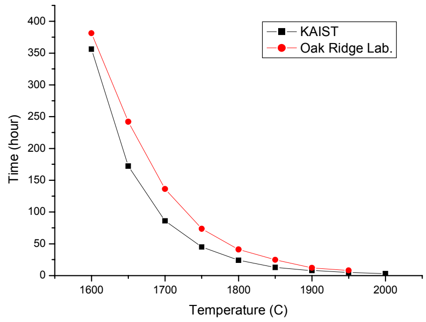

Fig. 2. Prediction of breakthrough time

Fig.2 shows the breakthrough time as temperature. As temperature goes on, breakthrough time decrease. A difference between the results and Oak Ridge Lab's results is around 7.94% (avg).

Using JAERI's experiment data at 1600°C and ZrC coating, diffusion coefficient is calculated. Result (D_{ZrC} (^{106}Ru)) is $1.66344*10^{-16}$ m^2/s. Diffusion coefficient of the reference (J.Nucl.Mater) is $1.8*10^{-16}$ m^2/s.[2] So this simulator is credible.

2.3 Parametric study

Parameter study is very meaningful work for calculating the fission product release. Each parameter (diameter, temperature, diffusion coefficient, etc.) is changed by situations and circumstances. Around 7 parameters are used for simulating real TRISO. Using these parameters, fractional release, breakthrough time and fission product concentration are obtained. unknown diffusion coefficient is calculated by using experimental data.

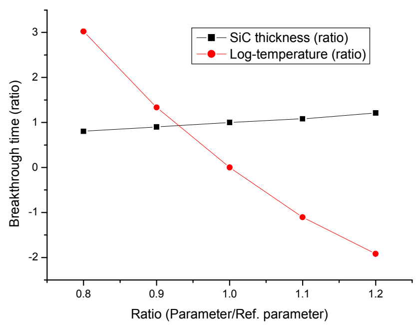

Fig. 3. Parametric analysis

3. Conclusions

A diffusion model for fission product release from TRISO particles is presented. A simple analytical model (hollow sphere) is used to get results. Developed simulator can calculate the fractional release and diffusion coefficient. The database about experimental results is made to get the unknown diffusion coefficient. After this time, outer region of TRISO is studied for analyzing the safety of HTGR

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