An Experiment on Specific Surface Area for Sintered Uranium Oxide with Additives of Nd_2O_3 and CeO_2

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1. Introduction

The fission gas diffusion coefficient is one of important parameters for nuclear fuel performance. It is usually obtained from the post irradiation annealing test using an irradiated fuel with a short time irradiation at a test reactor.[1] In order to calculate diffusion coefficient accurately, a specific surface area of the nuclear fuel sample is required.[2] In this study, some results of specific surface area measurements are treated for uranium oxide with some additives such as Nd_2O_3 and CeO_2 using TriStar-3000 system.[3] The additives are added with three different weights so as to investigate an effect of impurities. Before the main experiments, a system calibration was also performed using a reference material such as carbon powder.

2. Methods and Results

The specific surface area can be measured on the basis of the adsorption theory and is strongly dependent on the relative pressure.[3] The absorption is a phenomenon such as gas particles adhere to the surface or condense on the surface when gas molecules collide on the solid surface. The physical absorption is mainly controlled by the Van Der Waals force and chemical adsorptions are happened by the ion interaction or covalent electrons between solid surface and gas. From the analysis of the adsorption mechanism, we can obtain not only surface area but also pore characteristics such as size, volume and distribution. There are several theories on the adsorption phenomenon such as Langmuir theory and BET (Branauer, Emmett, Teller) theory.

TriStar-300 system is designed by Micromeritics and it uses the BET equation to obtain the specific surface area, which shows a linear equation as a function of relative pressure and adsorption volume. From the slope of the BET equation, adsorption volume and concentration are obtained. Degasser system such as FlowPrep060 was used to remove some impurities of the surface of a sample by heating up to 300 ^oC for 3 hours and flowing nitrogen gas. The liquid nitrogen was used in order to get adsorption of nitrogen gas in a sample holder.

Reference material was used in order to calibrate the system with carbon powder. Fig. 1 shows the BET equation which has a good linearity with a function of relative pressure. The reference specific surface area of the carbon power is 24.1 m^2/g. Total 6 tests have been carried out and their results were tabulated in Table I. The average specific surface area was obtained as 23.9 m^2/g. Therefore the system calibration error exhibits about 08 %, which shows the apparatus is quite reliable. The extended uncertainty was also estimated with considering A-type uncertainty with 95% confidence.

The simulated nuclear fuel was fabricated with two additives such as Nd_2O_3 and CeO_2 with three different kinds of weight compositions of 1.63 wt%, 3.25 wt%, and 6.51 wt%. Total weight of simulated fuel is about 0.3 g and the geometry is a pan-cake shape. Fig. 2 shows the BET equation for 6 kinds of simulated fuel and Table 2 shows the surface area results. The specific surface area of uranium oxide with Nd_2O_3 distributed between 0.51 m^2/g to 0.89 m^2/g. However, the Ce_2O added simulated fuels have the specific surface area of which range is from 0.40 m^2/g to 1.13 m^2/g. The linearity is slightly poor compared with that of reference material. And there is no trend with the amount of additives in the simulated fuel. These results may come from the sintered pellet of the sample. The sintered density of the sample is more than 95%, which is highly dense. The measuring system works well for powder or low density pellet. However, the specific surface area of the sintered simulated fuel could be estimated as 0.40 m^2/g to 1.13 m^2/g.

3. Conclusions

In this study, the surface area was obtained based on the BET theory and the specific surface area of the sintered pellet distributed about 0.7 m^2/g, which is much lower than powder sample. In order to investigate further, it is strongly recommended that structure analysis including SEM and optical microscopy should be followed for uranium oxide with oxide additives such as Nd_2O_3 and CeO_2. Analyzing the above results will be some basic data for the fission gas release behavior of the irradiated nuclear fuel.

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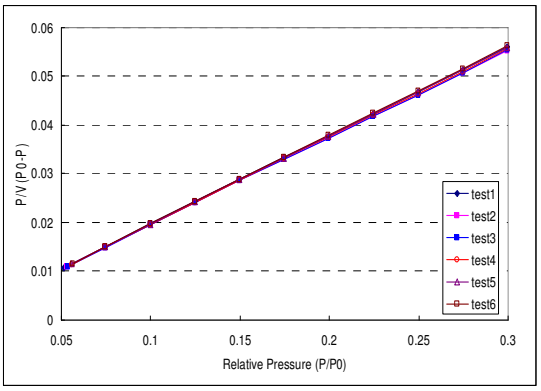

Fig. 1. BET equations for carbon powder.

Table I. Specific Surface Area for Carbon Powder

Cases	Specific Surface Area (m2/g)
test1	23.7263 (0.0512)*
test2	24.0981 (0.0637)
test3	24.0536 (0.0564)
test4	23.9367 (0.0520)
test5	23.7955 (0.0456)
test6	23.6673 (0.0495)
average	23.8796 (0.1307)**

* standard deviation, ** combined uncertainty

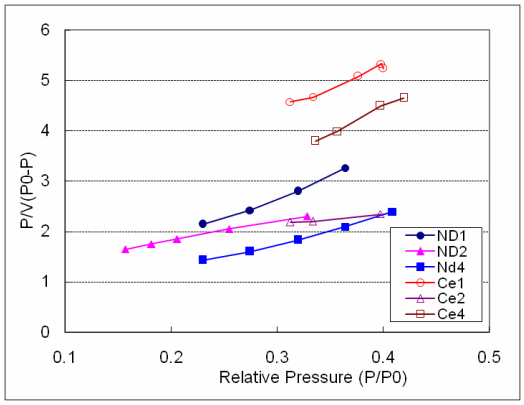

Fig. 2. BET equations for simulated fuels.

Table II. Specific Surface Area for Simulated Fuel

	Specific Surface Area (m2/g)		
	1.63 wt%	3.25 wt%	6.51 wt%
UO2+ Nd2O3	0.5100 (0.0409)*	0.8896 (0.0210)	0.7857 (0.0462)
UO2+ CeO2	0.4183 (0.0311)	1.1292 (0.1210)	0.3998 (0.0251)

* standard deviation