The Use of Recoil Fission Rare Gas for the Study of the Change in Crystal Structure

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Hahn[1] first investigated the emanation method which used radioactive inert gases $^{222}Rn(T_{1/2}=3.83$ d.), $^{220}Rn(T_{1/2}=54.5$ sec.) and $^{219}Rn(T_{1/2}=3.92$ sec.) as tracers. Since then, crystal structure changes and decomposition reactions were studied by this method[2]. In this method a parent of the radon nuclides is usually incorporated into a solid by coprecipitation with the solid or by deposition on the solid and the correlation between the escaped radioactive inert gas and crystal structure changes was studied.

In the present work, the radioactive fission product rare gases are used in place of radioactive radon nuclides. Uranium dioxide powder (particle size $\sim 0.2\,\mu$) is mixed with the solid powder to be examined, and the mixture is irradiated with thermal neutrons. When the weight ratio of uranium dioxide to the solid is 1 : 30, the fission recoil energy enables about 90% of the fission products to be caught by the surrounding solid powder. The captured fission product rare gases will behave in a similar manner as radon mentioned above, and they will be easily detected because of the relatively high fission-yield of radioactive xenon and krypton.

γ-Hematite or α-hematite and uranium dioxide powder of which the weight ratio is 30 : 1 were mixed and the mixture 500 mg. was irradiated for a total nvt of $\sim 3.5 \times 10^{15}$ thermal neutrons per cm^2 in an experimental hole of the JRR-1 reactor. After one-day cooling, the sample was placed in a quartz boat in a quarz tube which was connected with a phosphorus pentoxide drying tube, a dry ice trap (for radioactive iodine), a spiral counting cell inserted into an NaI scintillation crystal well of a γ-ray spectrometer and a flow rate meter, in the order mentioned. Pure helium gas was passed over the sample at a flow rate of 70 ml./min., and the sample was heated by a furnace surrounding the quartz tube at a rate of 5°C per minute. The radioactive xenon escaping from hematite was carried by helium and the radioactivity was measured by the γ-ray spectrometer which was previously adjusted to detect 250 keV. γ-ray of xenon-135 only. The plots of the radioactivity of xenon-135 escaped from γ-hematite and α-hematite versus temperature are shown in Figs. 1 and 2, respectively.

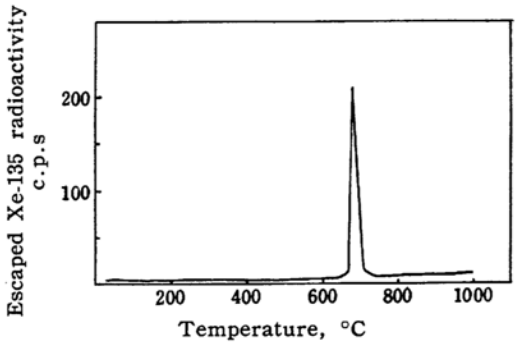

Fig. 1. Heating curve of γ-hematite. Heating rate, 5°C/min.

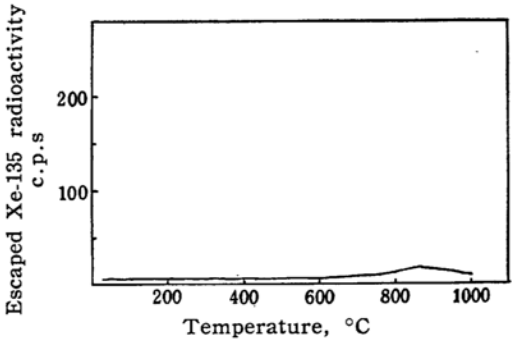

Fig. 2. Heating curve of α-hematite. Heating rate, 5°C/min.

The peak at 680°C of γ-hematite is considered to be related with the crystal change of γ-hematite to α-hematite. An X-ray diffraction method has shown that γ-hematite changes to α-hematite when the former is heated above the temperature at which a peak appears. In the case of α-hematite, the peak was not observed, because the crystal structure change is irreversible.

The previous data on the temperature of crystal structure change of γ-hematite to α-hematite are not in good agreement with the present result. The observed peak by the present method may shift with the heating rate, and the temperature

1) O. Hahn and O. Müller, *Z. Elektrochem.*, **29**, 189 (1923).
2) e. g., K. Zimens, *Z. physik. Chem.*, **B37**, 231 (1937).

of crystal structure change may be dependent on the preparation method and on impurities in γ-hematite.

The emanation method by the use of radioactive fission product rare gases will be applicable to many solids, even metals, because the samples can be prepared without chemical treatment, which are prerequisite to the radon emanation method.

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