Nuclear Spin-Isomer Transitions Excited by Synchrotron Radiation for the Case of the 31 Year Level of $^{178}Hf^{m2}$

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Nuclear spin-isomers can have high energies of internal excitation, high angular momenta, J, and long lifetimes against spontaneous decay. The 31 year isomer of $^{178}Hf^{m2}$ is a particularly interesting example. It stores 2.445 MeV per atom with J = 16. Theory has predicted that there should be transitions for the absorption of radiation that would excite such nuclei to higher energy states from which decay to the ground state would be accelerated. The rarity of actual samples has prevented any actual test of theory.

The first experiment in which a target containing nuclear spin-isomers was exposed to synchrotron radiation was conducted. Tuning the irradiation over the range 9000 to 13,000 eV proved expectations and accelerated the spontaneous decay of the nuclei. It was found that coupling of the electron and nuclear excitation increased the probability of absorption and broadened the width of the nuclear transition. Two examples are shown in Fig. 1.

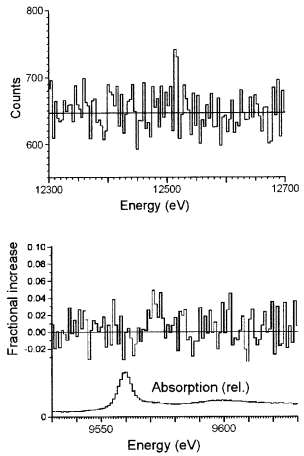

Fig.1 Intensities of γ-rays normally emitted by spontaneous decay of ^{178}Hf isomeric nuclei when irradiated with x-ray energies shown.

An XAFS Study on Room-temperature Reduction of Cerium Oxide Modified with Palladium

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When cerium oxide is modified with palladium by the deposition-precipitation method, the oxide can be significantly reduced with hydrogen at room temperature. The FT-EXAFS of Pd K-edge of 3 wt% Pd/CeO_2 as prepared showed a peak attributed to Pd-O at 1.6 Å and a peak attributed to Pd-Pd at 2.9 Å (Fig. 1). The coordination number of Pd-O was determined as 4.2 (1.99 Å) by curve-fitting. The distance of Pd-Pd was determined as 3.28 Å. The distance is the middle of 3.04 and 3.44 Å which are found in those of Pd-Pd interactions in PdO. The large Debye-Waller factor (0.076) suggests that the peak of Pd-Pd is the mixture of the two different Pd-Pd interactions.

The XAFS of the sample after contact with hydrogen for 1 h at room temperature changed drastically (see Fig. 1b). In the FT-EXAFS the magnitude of Pd-O interaction decreased and a peak at 2.5 Å attributed to Pd-Pd interaction. The Pd-Pd distance determined by curve-fitting was 2.70 Å, shorter than 2.75 Å found with Pd foil. The coordination number of Pd-Pd in the sample reduced at 573 K was 4.1 (2.72 Å), suggesting that the major part of the palladium particles are reduced with hydrogen at room temperature. However, the large coordination number of Pd-O (3.2) suggests that oxygen atoms cover the surface of the palladium particles.

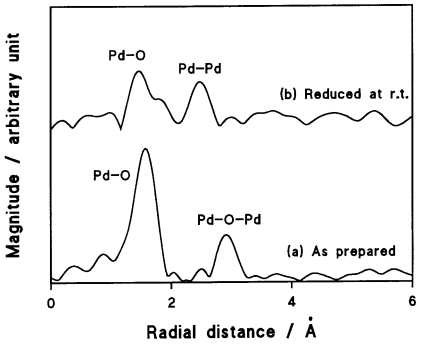

Fig. 1. FT-EXAFS of Pd K-edge for 3 wt% Pd/CeO2 prepared by the deposition-precipitation method.

Table 1. EXAFS parameters of 3 wt% Pd/CeO_2 prepared by the deposition-precipitation method.

Sample	interaction	R (Å)	CN	D.-W. factor
PdO	Pd-O	2.02	4.0	0.060
Pd foil	Pd-Pd	2.75	12.0	0.060
As prepared	Pd-O	1.99	4.2	0.060
As prepared	Pd-Pd	3.28	2.3	0.076
Reduced	Pd-O	1.99	3.2	0.097
Reduced	Pd-Pd	2.70	4.1	0.111