CHEMISTRY LETTERS, pp. 349-350, 1991.

Hydrogen Species Adsorbed on an Sm_2O_3 Catalyst Observed by Infrared Spectroscopy

Yoshihisa SAKATA,* Hayao IMAMURA, and Susumu TSUCHIYA
Department of Advanced Materials Science and Engineering, Faculty of Engineering, Yamaguchi University, 2557 Tokiwadai, Ube 755

The characteristic hydrogen species adsorbed on a well-outgassed Sm_2O_3 surface at 300 K are observed by infrared spectroscopy. The infrared bands of these species were observed at 822 cm^{-1} and 714 cm^{-1}.

The lanthanide oxide catalysts have interesting properties and have been applied to various reactions.[1-4] Especially, one of the characteristic property of these catalyst systems is the higher activity of the ethene hydrogenation at low temperatures.[2,3] The hydrogen activation over their surface is one of the important factor to elucidate the hydrogenation reactions as well as their surface states. The hydrogen species on some oxides have been observed by infrared spectroscopy[5-7] and sometimes play the significant role of the hydrogenation reaction.

In this work, we have studied the adsorption of hydrogen on Sm_2O_3, and have observed characteristic hydrogen adsorbed species by infrared spectroscopy.

Self-supporting disk of Sm_2O_3 which prepared from $Sm_2(NO_3)_3$ (ca. 60 mg) set in quartz IR cell. The catalyst was treated with O_2 and H_2 at 873 K respectively and then evacuated at 1100 K for several minutes in the cell. Infrared spectra were recorded with FT/IR 7000 (JASCO.). All spectra were measured at 4 cm^{-1} resolution and obtained from the ratio of the background spectrum of Sm_2O_3 to that of the adsorbed gases.

Infrared spectra of surface species formed from the adsorption of deuterium and hydrogen at 300 K were shown in Fig. 1. The bands at 3661, 822, and 714 cm^{-1} were observed after exposing H_2 as shown in Fig. 1(a). From Fig. 1(a)-(c), it is clear that the intensities of the bands at 822 and 714 cm^{-1} depend on the pressure of H_2 but the band at 3661 cm^{-1} was independent of the pressure of H_2. When deuterium was exposed to the surface, the bands at 2722, 2700, and 2678 cm^{-1} due to O-D were observed but the bands at 822 and 714 cm^{-1} were disappeared as shown in Fig. 1(d). If these bands were attributable to hydrogen, the corresponding bands of the deuterium species shifted to out of the spectral regions that can be measured for the Sm_2O_3. It was also confirmed that these two bands were gradually decreased with increasing the temperature and were almost disappeared at 373 K under 13 kPa of hydrogen atmosphere. From these results, the bands at 822 and 714 cm^{-1} can be assigned to the adsorbed hydrogen species over Sm_2O_3. Generally, for the heterolytic splitted hydrogen adsorbed on oxides,[5,7] if these species desorbed, the IR bands due to metal hydride and hydroxide were decreased correspondingly. In this case, there has no relation between the intensity of the bands due to the hydride and hydroxide. It is clear that the hydride species observed in this work has a characteristic properties compared to the heterolytic adsorbed hydride. In some cases infrared bands due to hydride over oxide surfaces were appeared below 1000 cm^{-1} and were supposed to assign the bridged or multi-holded hydrogen between the metal ions like the adsorbed hydrogen on Cu-Zn-Cr mixed oxide.[8] It also suggests that the bridged or multi-holded hydrogen adsorbed species were formed over the Sm_2O_3 surface.

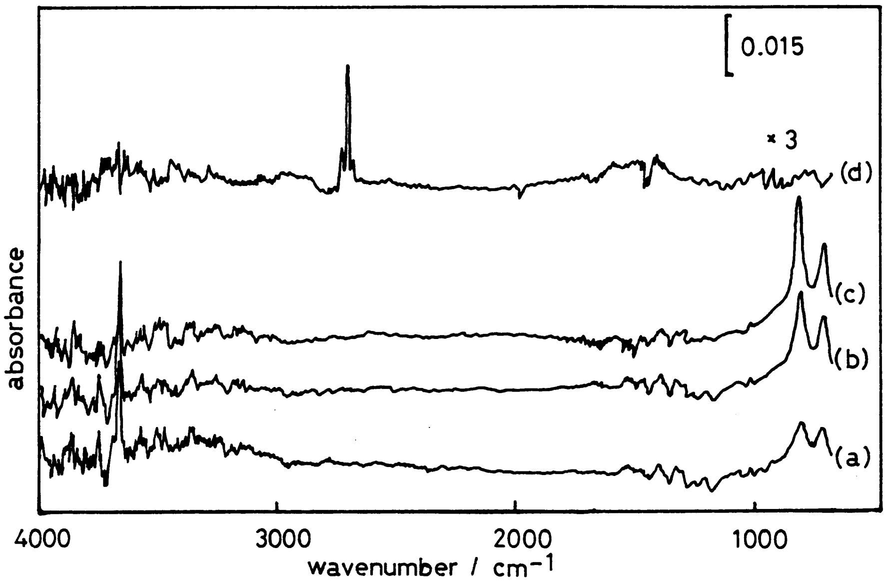

Fig. 1. Infrared Spectra of surface species on Sm_2O_3 formed from adsorption of hydrogen (a) 133 Pa, (b) 1.3 kPa and (c) 10 kPa, and adsorption of deuterium under 13 kPa(d).

References
1) Y. Sakata, M. Yoshino, H. Imamura, and S. Tsuchiya, J. Chem. Soc., Faraday Trans., 86, 3489 (1990). 2) KH. M. Minachev, Yu. S. Khodakov, and V. S. Nakhshunov, J. Catal., 49, 207 (1977). 3) T. Arai, K. Maruya, K. Domen, and T. Onishi, Bull. Chem. Soc. Jpn., 62, 349 (1989). 4) S. Bernal and J. M. Trillo, J. Catal., 66, 184 (1980). 5) C. C. Chang and R. J. Kokes, J. Am. Chem. Soc., 93, 7017 (1971). 6) S. Coluccia, F. Boccuzzi, G. Ghiotti, and C. Morterra, J. Chem. Soc., Faraday Trans. 1, 78, 2111 (1982). 7) T. Onishi, H. Abe, K. Maruya, and K. Domen, J. Chem. Soc., Chem. Commun., 1985, 617. 8) G. Busca and A. Vaccari, J. Chem. Soc., Chem. Commun., 1988, 788.

(Received October 29, 1990)