

Effect of H atoms on ethylene adsorption on Pt(110) studied by NEXAFS spectroscopy

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Introduction

Hydrogenation of ethylene on Pt-group metal surfaces is one of the most important industrial catalytic processes and has been extensively studied both experimentally and theoretically. Two adsorption species have been identified for ethylene adsorption; π -bonded species and di- σ -bonded one. It has been suggested that π -bonded ethylene plays an important role in the hydrogenation process. But there has been little information on the structure of the π -bonded ethylene on Pt(110). For this reason we investigated ethylene adsorption on clean and H-precovered Pt(110) surfaces by means of C K-NEXAFS.

It is known that the surfaces of the clean and H-covered Pt(110) are reconstructed into corrugated (1x2) structures with inclined (111) microfacets (see Fig.2).

Experimental

The experiments were carried out at BL-7A with an UHV system. Saturated overlayers of ethylene were prepared on the clean and H-precovered (1x2)-Pt(110) surfaces at 130 K. C K-edge NEXAFS spectra were taken with the partial electron yield mode at polar angles of 90°, 55°, and 15° for two azimuthal directions: the E vector \parallel [110] and \parallel [001]. We also measured NEXAFS spectra of ethylene adsorbed on Pt(111) surfaces for comparison.

Results and discussion

Fig. 1 shows C K-NEXAFS spectra for ethylene overlayers on clean and H-covered surfaces. For each spectrum, two π^* and σ^* (C-C) peaks are observed. They are

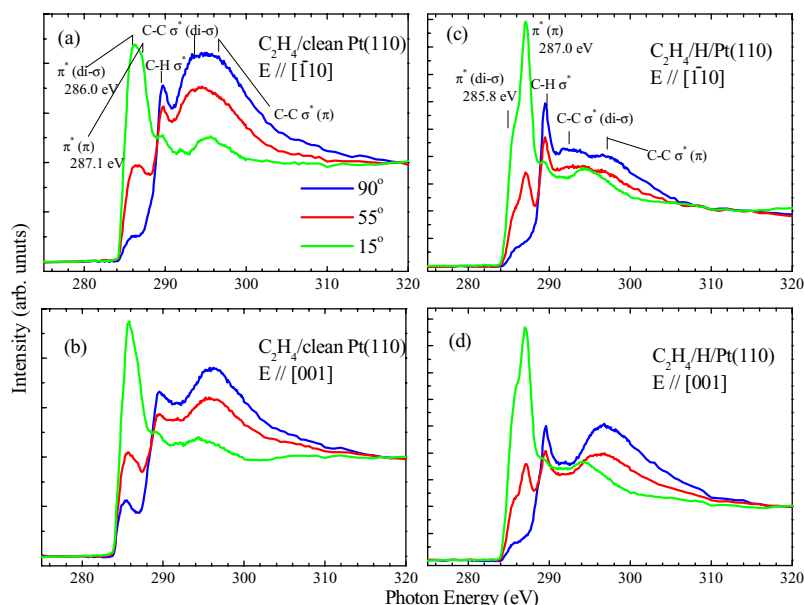


Fig. 1. C K-NEXAFS spectra from clean (a, b) and H-covered (c, d) Pt(110) surfaces with the E vector \parallel [110] and \parallel [001].

assigned by referring the previous studies using vibrational spectroscopy [1], as shown in Fig. 1.

The π -bonded ethylene is expected to be adsorbed on the atop site of the highest atomic row of the (1x2) reconstructed surfaces [1]. The polarization dependence of the π^* peak shows that the C-C axis of the π -bonded ethylene is almost parallel to the surface for both clean and H-covered surfaces. The σ^* (C-C) peak of the π -bonded species is stronger at $E \parallel$ [110] than at $E \parallel$ [001] on the clean surface, while the spectral situation is just opposite on the H-precovered surface. This indicates that the π -bonded ethylene prefers to be aligned to the [110] azimuth on the clean surface and rotates to the [001] direction on H co-adsorption, as shown in Fig. 2. This change might come from the electrostatic repulsion between ethylene molecules and bridge-bonded H atoms.

The di- σ -bonded species is likely to be adsorbed on the (111) microfacet because its peak positions are the same as those of ethylene adsorbed on Pt(111) surfaces. This agrees with the previous observation [1]. There is no significant orientational change observed on H coadsorption.

Reference

[1]E.Yagasaki et al., J. Vac. Sci Technol. A 8, 2612 (1990).

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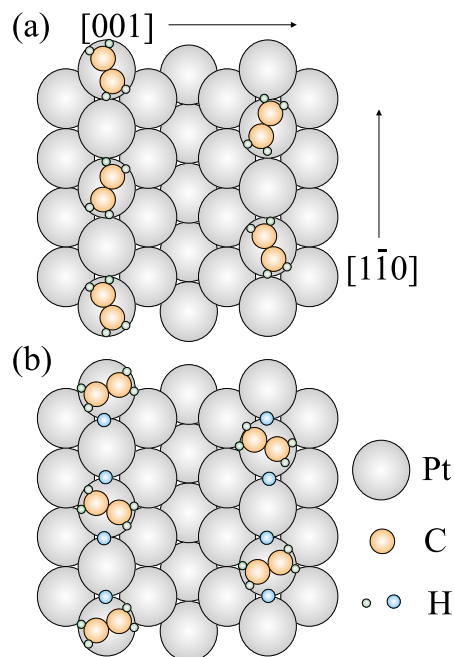


Fig. 2. Proposed structural models for the π -bonded ethylene on the (a) clean and (b) H-covered (1x2)-Pt(110) surfaces