EXAFS study on Ca compounds in tribofilm generated from belt-drive continuously variable transmission fluid

Souichirou KONNO*[1], Yoshimu IWANAMI[1], Nobuharu KIMURA[1], Hiroshi KAMETSUKA[1], Shin MIYAGI[1], Makoto NAKAMURA[1], Yasuhiro INADA[2], Masaharu NOMURA[2]
[1]Nippon Oil Corporation, 8, Chidoricho Naka-ku, Yokohama, 231-0815, Japan
[2]KEK-PF, Tsukuba, Ibaraki 305-0801, Japan

Introduction

Belt-drive continuously variable transmissions (CVTs) have attracted attention because they give better fuel efficiency than conventional automatic transmissions (ATs). Belt-drive CVT fluids (belt-drive CVTFs) must have not only the same physical properties as ATs, such as oxidation stability, but also high friction coefficients between the metallic belt and pulley in the transmission system to convey forces efficiently [1]. The additives in CVTFs react with metal surfaces to form tribofilms. In order to design high performance belt-drive CVTFs, it is necessary to investigate the nature of the tribofilms that govern friction coefficients.

Here, we focused on Ca which is one of the elements contained in the additives in CVTFs and report on the Ca K-edge fluorescence EXAFS measurements of the tribofilms using a 19-element Ge detector.

Experimental

The block-on-ring friction test [2] was employed to prepare tribofilms and measure the friction coefficients of 2 kinds of test fluids (Table 1). The test condition is described elsewhere [2]. The tribofilm was then subjected to EXAFS measurements. The Ca K-edge EXAFS measurements in the fluorescence yield mode were carried out at BL-9A. The spectra were collected using both a Lytle detector and a 19-element Ge detector equipped with a solar-slit system.

Table 1: Friction coefficients of test fluids

Test fluid	Friction coefficient	Concentration (mass ppm)		
		Ca	P	S
CVTF-1	0.138	500	200	900
CVTF-2	0.141	1300	600	5000

Results and Discussion

When EXAFS spectra of the tribofilms were collected using a Lytle detector, the shapes of spectra were unsual at low and high energy regions shown in Fig.1. This is supposed to arise from the diffractions or the scatterings from the steel substrates (Fe) where the tribofilms form. Thus it was impossible to obtain the Fourier Transform of EXAFS.

Therefore, a 19-element Ge detector was employed in order to separate the Ca fluorescence from the diffractions or the scatterings from the steel substrates. The shapes of EXAFS spectra collected using the Ge detector varied depending on the positions of the sample, the element in the Ge unit and the solar slit. As a result of the optimization of the positions of the sample, the element and the slit, good EXAFS spectra of the tribofilms were obtained. Then, the Fourier Transforms of Ca K-edge EXAFS of two tribofilms were successfully carried out (Fig.2).

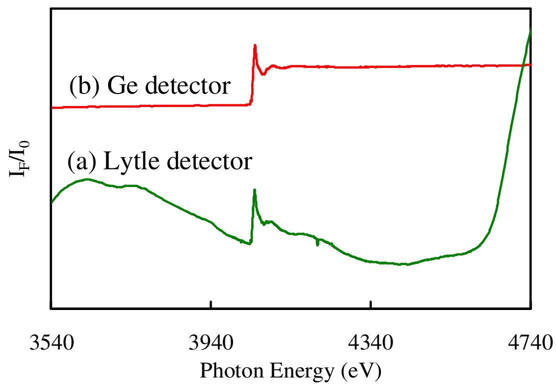

Fig.1 Ca K-edge EXAFS spectra of CVTF-1 collected using two detectors.

The shapes of the Fourier Transforms of the tribofilms generated from CVTF-1 and CVTF-2 were similar each other. This suggests that chemical states and structures of Ca compounds in the two tribofilms might be similar and might not greatly affect the friction coefficients of the tribofilms.

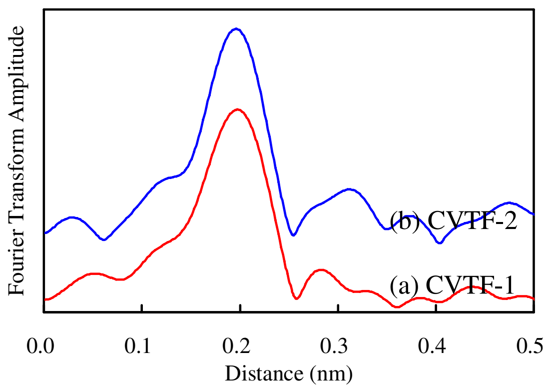

Fig.2 Fourier Transforms of Ca K-edge EXAFS of the tribofilms.

References

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* souichirou.konno@eneos.co.jp